SOIL SURVEY OF

Canadian County, Oklahoma

United States Department of Agriculture
Soil Conservation Service
in cooperation with
Oklahoma Agricultural Experiment Station

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in the period 1964–72. Soil names and descriptions were approved in 1972. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1972. This survey was made cooperatively by the Soil Conservation Service and the Oklahoma Agricultural Experiment Station. It is part of the technical assistance furnished to the East Canadian County Conservation District, Central North Canadian River Conservation District, and North Caddo Conservation District.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms, ranches, and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Canadian County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and shows the capability classification of each. It also shows the pasture and hay and tree groups and the page for the description of the range site to which the soil has been assigned.

Individual colored maps that show the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those that have a moderate limitation can be colored yellow, and those that have a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the descriptions of the range sites and the pasture and hay and tree groups.

Foresters and others can refer to the section "Trees," where the soils of the county are grouped according to their suitability for trees.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Wildlife Habitat."

Ranchers and others can find, under "Range," groupings of the soils according to their suitability for range and, also, the names of many of the plants that grow on each range site.

Community planners and others can read about soil properties that affect the choice of sites for dwellings, industrial buildings, and recreation areas in the sections "Engineering" and "Recreation."

Engineers and builders can find, under "Engineering," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers in Canadian County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county in the section "Climate."

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SOIL SURVEY OF CANADIAN COUNTY, OKLAHOMA

BY CARL F. FISHER AND BILL SWAFFORD, SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH OKLAHOMA AGRICULTURAL EXPERIMENT STATION

CANADIAN COUNTY is in the central part of Oklahoma (fig. 1). It is bounded on the west by Caddo and Blaine Counties, on the north by Blaine and Kingfisher Counties, on the east by Oklahoma and Cleveland Counties, and on the south by Caddo and Grady Counties. El Reno, the county seat, is in the central part of the county.

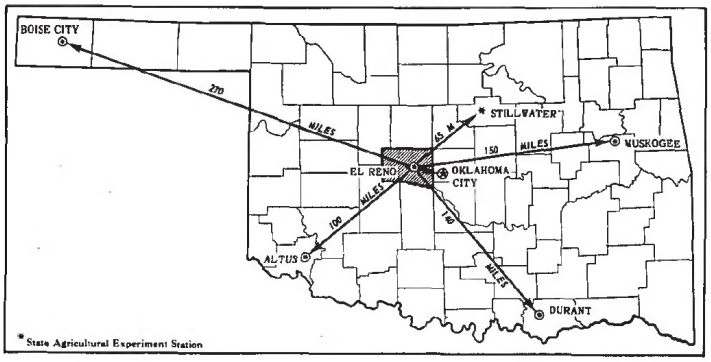

Figure 1.—**Location of Canadian County in Oklahoma.**

The county has an area of 575,360 acres, or 899 square miles. It lies within the Central Rolling Red Prairies land resource area. The area is dominantly rural, and raising livestock is the main enterprise. Small grain, alfalfa, and grain sorghum are commonly grown.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Canadian County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes; the size and speed of streams; the kinds of native plants or crops; the kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The soil series and the soil phase are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Bethany and Norge, for example, are the names of two soil series in Canadian County. All the soils in the United States that have the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Kingfisher silt loam, 3 to 5 percent slopes, is one of several phases within the Kingfisher series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series or of different phases within one series. One such kind of mapping unit, the soil complex, is shown on the soil map of Canadian County.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Nash-Quinlan complex, 3 to 8 percent slopes, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. The Rock outcrop part of Quinlan-Rock outcrop complex, 12 to 30 percent slopes, is an example.

While a soil survey is in progress, soil scientists take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kind of soil in other places are also assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kind of soil. Yields under defined management are estimated for all the soils.

Soil scientists observe how soils behave when used as a growing place for native and cultivated plants and as material for structures, foundations for structures, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this failure to the slow permeability of the soil or to a high water table. They see that streets, road pavements, and foundations for houses are cracked on a named kind of soil, and they relate this failure to the high shrink-swell potential of the soil material. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential uses.

After data have been collected and tested for the key, or benchmark, soils in a survey area, the soil scientists set up trial groups of soils. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. They then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Canadian County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map that shows soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in this survey have been grouped into three general kinds of landscapes for broad interpretative purposes. Each of the broad groups and their included soil associations are described on the following pages. The terms for texture used in the title for several of the associations apply to the texture of the surface layer. For example, in the title of association 1, the word "loamy" refers to the texture of the surface layer.

The soil associations in Canadian County are described on the following pages.

Deep, Well-Drained Loamy and Sandy Soils on Uplands

The three associations in this group make up about 63 percent of Canadian County. The soils are used mainly for field crops. They are used less extensively for tame pasture and range.

1. *Norge-Bethany association*

Deep, well-drained, nearly level to sloping loamy soils that have a clayey and loamy subsoil

This association makes up about 40 percent of the county. It is about 42 percent Norge soils, 18 percent Bethany soils, and 40 percent less extensive soils, mostly Binger, Grant, Hinkle, Kingfisher, Kirkland, Minco, and Pond Creek soils.

Norge soils are chiefly on crests and side slopes. They are deep, very gently sloping to sloping, and well drained. They have a loamy surface layer and a loamy subsoil underlain by loamy sediments.

Bethany soils are mainly on broad crests. They are deep, nearly level, and well drained. They have a loamy surface layer and a loamy or clayey subsoil underlain by loamy or clayey sediments.

Most of this association is used for wheat. It is also suited to small grain, cotton, grain sorghum, alfalfa, peanuts, tame pasture grasses, and native grasses.

The chief management objectives are maintaining fertility and soil structure and keeping erosion within allowable limits. Terracing the sloping soils, managing crop residue, and adding plant nutrients are the chief management needs.

2. *Renfrow-Kirkland association*

Deep, well-drained, nearly level to gently sloping loamy soils that have a clayey subsoil

This association makes up about 13 percent of the county. It is about 37 percent Renfrow soils, 32 percent Kirkland soils, and 31 percent less extensive soils, mostly Bethany, Grant, Hinkle, Kingfisher, Pond Creek, and Shellabarger soils.

Renfrow soils are chiefly on crests and side slopes. They are deep, nearly level to gently sloping, and well drained. They have a loamy surface layer and a clayey subsoil underlain by shale or clayey sediments.

Kirkland soils are chiefly on crests. They are nearly level to very gently sloping and well drained. They have a loamy surface layer and a clayey subsoil underlain by shale or clayey sediments.

Most of this association is used for wheat. It is also suited to small grain, cotton, grain sorghum, tame pasture grasses, and native grasses.

The chief management objectives are controlling runoff, conserving moisture, maintaining soil structure and fer-

tility, and controlling erosion. Managing crop residue, adding plant nutrients, and terracing the sloping soils are the chief management needs.

3. *Shellabarger-Konawa association*

Deep, well-drained, very gently sloping to strongly sloping loamy and sandy soils that have a loamy subsoil

This association makes up about 10 percent of the county. It is about 47 percent Shellabarger soils, 10 percent Konawa soils, and 43 percent less extensive soils, mostly Albion, Binger, Darnell, Grandfield, Grant, Kingfisher, Noble, Norge, and Pond Creek soils.

Shellabarger soils are chiefly on crests and side slopes. They are deep, very gently sloping to strongly sloping, and well drained. They are loamy throughout.

Konawa soils are chiefly on crests and side slopes. They are deep, gently sloping to sloping, and well drained. They have a sandy surface layer and a loamy subsoil underlain by sandy or loamy sediments.

Most of this association is used for alfalfa, small grain, grain sorghum, peanuts, and tame pasture grasses. It is also suited to native grasses.

The chief management objectives are maintaining soil structure and fertility and keeping erosion within allowable limits. These soils respond favorably to good management.

Shallow to Deep, Well Drained and Somewhat Excessively Drained Loamy and Clayey Soils on Uplands

The three associations in this group make up about 14 percent of Canadian County. The soils are used mostly for range. They are used less extensively for tame pasture and field crops.

4. *Nash-Quinlan association*

Moderately deep and shallow, well-drained, gently sloping to steep loamy soils that have a loamy subsoil

This association makes up about 6 percent of the county. It is about 29 percent Nash soils, 21 percent Quinlan soils, and 50 percent less extensive soils, mostly Darnell, Dill, Grant, Kingfisher, Minco, Norge, Pond Creek, Port, Shellabarger, and Vernon soils.

Nash soils are chiefly on crests and side slopes between areas of Quinlan soils. They are moderately deep, gently sloping to sloping, and well drained. They have a loamy surface layer and subsoil underlain by sandstone.

Quinlan soils are chiefly on crests and side slopes between areas of Rock outcrop and Nash and other soils. They are shallow, gently sloping to steep, and well drained. They have a loamy surface layer and subsoil underlain by sandstone.

Most of this association is used for native grasses. Some of the less sloping soils are also used for small grain, grain sorghum, and tame pasture grasses.

The chief management objectives are to keep grasses growing vigorously and, in cultivated areas, to maintain soil structure and fertility and keep erosion within allowable limits.

5. *Darnell-Minco association*

Shallow and deep, somewhat excessively drained and well drained, very gently sloping to steep loamy soils that have a loamy subsoil

This association makes up about 6 percent of the county. It is about 29 percent Darnell soils, 25 percent Minco soils, and 46 percent less extensive soils, mostly Dill, Grandfield, Grant, Nash, Noble, Port, Quinlan, and Shellabarger soils and Rock outcrop.

Darnell soils are on crests and side slopes between areas of other soils. They are shallow, very gently sloping to steep, and somewhat excessively drained. They have a loamy surface layer and subsoil underlain by sandstone.

Minco soils are chiefly on crests and side slopes. They are deep, very gently sloping to steep, and well drained. They are loamy throughout.

Most of this association is used for native grasses. Some of the less sloping soils are also used for small grain, cotton, grain sorghum, peanuts, and tame pasture grasses.

The chief management objectives are to keep grasses growing vigorously and, in cultivated areas, to maintain soil structure and fertility and keep erosion within allowable limits.

6. *Vernon association*

Moderately deep, well-drained, gently sloping to moderately steep clayey and loamy soils that have a clayey subsoil

This association makes up about 2 percent of the county. It is about 50 percent Vernon soils and 50 percent less extensive soils, mostly Kingfisher, Kirkland, Renfrow, Shellabarger, and Yahola soils and Rock outcrop.

Vernon soils are chiefly on narrow crests and side slopes. They are moderately deep, gently sloping to moderately steep, and well drained. They have a clayey and loamy surface layer and a clayey subsoil underlain by shale and clayey sediments.

Most of this association is used for native grasses. Some of the less sloping soils are also suited to small grain, grain sorghum, and tame pasture grasses.

The chief management objectives are to keep grasses growing vigorously and, in cultivated areas, to keep erosion within allowable limits, conserve soil moisture, and maintain soil structure and fertility. Managing crop residue, adding plant nutrients, and terracing are the chief management needs in cultivated areas.

Deep, Well Drained to Somewhat Poorly Drained Clayey to Sandy Soils on Flood Plains

The three associations in this group make up about 23 percent of Canadian County. The soils are used mainly for field crops. They are used less extensively for tame pasture and range.

7. *Dale-Canadian association*

Deep, well-drained, nearly level loamy soils that have a loamy subsoil

This association makes up about 9 percent of the county. It is about 40 percent Dale soils, 32 percent Canadian soils, and 28 percent less extensive soils, mostly Brewer, Gracemore, McLain, Reinach, Watonga, and Yahola soils and areas of water.

Dale soils are chiefly in higher areas of flood plains adjacent to the uplands. They are deep, nearly level, and well drained. They are loamy throughout.

Canadian soils are chiefly in higher areas of flood plains. They are deep, nearly level, and well drained. They are loamy throughout.

Most of this association is used for small grain, cotton, grain sorghum, and peanuts. It is also suited to tame pasture grasses and native grasses.

The chief management objective is maintaining soil structure and fertility. These soils respond favorably to good management.

8. *Watonga-Brewer association*

Deep, moderately well drained, nearly level soils that are dominantly clayey throughout and loamy soils that have a loamy and clayey subsoil

This association makes up about 2 percent of the county. It is about 37 percent Watonga soils, 30 percent Brewer soils, and 33 percent less extensive soils, mostly Canadian, Dale, Drummond, McLain, and Reinach soils.

Watonga soils are chiefly in higher areas of flood plains. They are deep, nearly level, and moderately well drained. They have a clayey surface layer over a clayey or loamy layer underlain by clayey sediments.

Brewer soils are chiefly in higher areas of flood plains. They are deep, nearly level, and moderately well drained. They have a loamy surface layer and a loamy and clayey subsoil underlain by loamy sediments.

Most of this association is used for small grain, cotton, alfalfa, grain sorghum, and tame pasture grasses. It is also suited to native grasses.

The chief management objectives are maintaining soil structure and fertility and controlling surface wetness.

9. *Port-Gracemore association*

Deep, well drained and somewhat poorly drained, nearly level loamy and sandy soils that have a loamy subsoil and sandy and loamy underlying material

This association makes up about 12 percent of the county. It is about 40 percent Port soils, 37 percent Gracemore soils, and 23 percent less extensive soils, mostly Brewer, Canadian, Dale, McLain, Reinach, Tivoli, Watonga, and Yahola soils and areas of water.

Port soils are on flood plains. They are deep, nearly level, and well drained. They are loamy throughout.

Gracemore soils are on flood plains. They are deep, nearly level, and somewhat poorly drained. They are sandy and loamy soils that are underlain by sandy and loamy sediments.

Most of this association is used for small grain, cotton, grain sorghum, and tame pasture grasses. It is also suited to native grasses.

The chief management objectives are controlling flooding and maintaining soil structure and fertility.

Descriptions of the Soils

In this section the soils of Canadian County are described in detail and use and management suggested. Each soil series is described in detail and then, briefly, the mapping units in that series. Unless specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile; that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. Color terms are for dry soil unless otherwise stated. The profile described in the soil series is representative of mapping units in that series. If a given mapping unit has a profile in some way different from the one described, these differences are stated in the description of the mapping unit, or they are apparent in the name of the mapping unit. The description of each mapping unit contains suggestions about how the soil can be managed.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Rock outcrop, for example, does not belong to a soil series but, nevertheless, is listed in alpabetic order along with the soil series.

Preceding the name of each mapping unit is a symbol. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit are the capability unit, pasture and hay group, range site, and tree group in which the mapping unit has been placed. The page for the description of each range site can be learned by referring to the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*6*).[1]

Albion Series

The Albion series consists of sloping to strongly sloping soils on uplands. These soils formed under a cover of grasses in material weathered from loamy sediments.

In a representative profile the surface layer is brown fine sandy loam about 10 inches thick. The subsoil extends to a depth of 37 inches. The upper 10 inches is reddish-brown sandy loam, and the lower 17 inches is yellowish-red sandy loam. The underlying material is yellowish-red gravelly sandy loam and loamy sand to a depth of 72 inches.

Albion soils are well drained. Permeability is moderately rapid, and the available water capacity is medium. The water table is at a depth of more than 6 feet.

Representative profile of Albion fine sandy loam in an area of Shellabarger-Albion complex, 5 to 12 percent slopes, 1,500 feet west and 500 feet north of the southeast corner of sec. 29, T. 12 N., R. 9 W.

A1—0 to 10 inches, brown (7.5YR 4/2) fine sandy loam, dark brown (7.5YR 3/2) moist; moderate, fine, granular structure; slightly hard, friable; few coarse fragments less than 3 inches in diameter; slightly acid; clear, smooth boundary.

[1] Italic numbers in parentheses refer to Literature Cited, p. 62.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil name	Area	Extent	Soil name	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Bethany silt loam, 0 to 1 percent slopes	43, 508	7. 6	Nash-Quinlan complex, 3 to 8 percent slopes	13, 200	2. 3
Binger fine sandy loam, 1 to 5 percent slopes	2, 900	. 5	Nash-Quinlan complex, 3 to 8 percent slopes, eroded	5, 700	1. 0
Brewer silty clay loam	4, 500	. 8	Nash-Quinlan complex, 3 to 8 percent slopes, severely eroded	1, 300	. 2
Brewer-Drummond complex	3, 500	. 6	Noble fine sandy loam, 3 to 5 percent slopes	4, 100	. 7
Canadian fine sandy loam	17, 100	3. 0	Norge silt loam, 1 to 3 percent slopes	49, 500	8. 6
Dale silt loam	24, 200	4. 2	Norge silt loam, 3 to 5 percent slopes	47, 200	8. 2
Darnell-Noble complex, 1 to 8 percent slopes	6, 800	1. 2	Norge silt loam, 5 to 8 percent slopes	4, 200	. 7
Darnell-Noble complex, 8 to 30 percent slopes	10, 500	1. 8	Pond Creek silt loam, 0 to 1 percent slopes	18, 800	3. 3
Dill-Quinlan complex, 5 to 8 percent slopes	4, 600	. 8	Pond Creek silt loam, 1 to 3 percent slopes	7, 300	1. 3
Gracemore loamy fine sand, occasionally flooded	16, 200	2. 8	Port silt loam	18, 900	3. 3
Gracemore soils, frequently flooded	9, 700	1. 7	Port soils, frequently flooded	6, 400	1. 1
Grandfield fine sandy loam, 1 to 3 percent slopes	1, 100	. 2	Quinlan-Dill complex, 5 to 12 percent slopes	1, 500	. 3
Grandfield fine sandy loam, 3 to 5 percent slopes	2, 500	. 4	Quinlan-Rock outcrop complex, 12 to 30 percent slopes	5, 000	. 9
Grandfield fine sandy loam, 2 to 6 percent slopes, eroded	1, 300	. 2	Reinach very fine sandy loam	7, 000	1. 2
Grandfield fine sandy loam, 5 to 8 percent slopes	1, 000	. 2	Renfrow silt loam, 0 to 1 percent slopes	2, 400	. 4
Grandfield soils, 3 to 8 percent slopes, severely eroded	2, 500	. 4	Renfrow silt loam, 1 to 3 percent slopes	9, 400	1. 6
Grant-Hinkle complex, 1 to 3 percent slopes	6, 400	1. 2	Renfrow clay loam, 2 to 5 percent slopes, eroded	17, 300	3. 0
Grant-Port complex, 0 to 12 percent slopes	24, 300	4. 2	Shellabarger fine sandy loam, 1 to 3 percent slopes	14, 900	2. 6
Grant-Quinlan complex, 5 to 8 percent slopes	6, 100	1. 1	Shellabarger fine sandy loam, 3 to 5 percent slopes	11, 100	1. 9
Grant-Quinlan complex, 3 to 8 percent slopes, eroded	2, 150	. 4	Shellabarger fine sandy loam, 5 to 8 percent slopes	1, 100	. 2
Kingfisher silt loam, 1 to 3 percent slopes	16, 200	2. 8	Shellabarger fine sandy loam, 3 to 8 percent slopes, eroded	4, 500	. 8
Kingfisher silt loam, 3 to 5 percent slopes	20, 400	3. 5	Shellabarger-Albion complex, 5 to 12 percent slopes	2, 800	. 5
Kirkland silt loam, 0 to 1 percent slopes	14, 500	2. 5	Tivoli fine sand	4, 100	. 7
Kirkland silt loam, 1 to 3 percent slopes	10, 800	1. 9	Vernon clay loam, 3 to 5 percent slopes	4, 100	. 7
Kirkland-Hinkle complex, 0 to 3 percent slopes	2, 900	. 5	Vernon-Rock outcrop complex, 5 to 15 percent slopes	5, 800	1. 0
Konawa loamy fine sand, 3 to 8 percent slopes	6, 400	1. 1	Vernon soils, 3 to 5 percent slopes, eroded	1, 800	. 3
McLain silty clay loam	4, 600	. 8	Watonga silty clay	6, 150	1. 1
Minco very fine sandy loam, 5 to 8 percent slopes	5, 300	. 9	Yahola fine sandy loam	7, 600	1. 3
Minco very fine sandy loam, 8 to 30 percent slopes	4, 500	. 8	Water	1, 152	. 2
Minco silt loam, 1 to 3 percent slopes	4, 800	. 8			
Minco silt loam, 3 to 5 percent slopes	9, 800	1. 7	Total	575, 360	100. 0

B2t—10 to 20 inches, reddish-brown (5YR 5/4) sandy loam, reddish brown (5YR 4/4) moist; moderate, medium, prismatic structure; hard, friable; patchy clay films on faces of peds; few coarse fragments less than 3 inches in diameter; neutral; gradual, smooth boundary.

B3—20 to 37 inches, yellowish-red (5YR 5/6) sandy loam, yellowish red (5YR 4/6) moist; weak, medium, prismatic structure; hard, very friable; patchy clay films on faces of peds; few coarse fragments less than 3 inches in diameter; mildly alkaline; abrupt, smooth boundary.

IIC1—37 to 52 inches, yellowish-red (5YR 5/6) gravelly sandy loam, yellowish red (5YR 4/6) moist; massive; hard, very friable; about 40 percent, by volume, coarse fragments less than 3 inches in diameter; few films of secondary carbonates; calcareous; moderately alkaline; abrupt, smooth boundary.

IIC2—52 to 72 inches, yellowish-red (5YR 5/6) loamy sand, yellowish red (5YR 4/6) moist; massive; hard, very friable; few coarse fragments less than 3 inches in diameter; bedding planes are evident; few films of secondary carbonates; calcareous; moderately alkaline.

Depth to sand and gravel ranges from 20 to 40 inches. Depth to soft, powdery secondary carbonates is more than 36 inches. The A1 or Ap horizon is brown or dark brown. The B2t horizon is reddish brown, strong brown, reddish yellow, dark yellowish brown, or yellowish brown. It is slightly acid or neutral. The B3 horizon is similar to the B2t horizon in color, but it ranges from slightly acid to mildly alkaline. The IIC horizon is reddish-brown, red, or yellowish-red gravelly sandy loam, loamy sand, or gravelly loamy sand. It is neutral to moderately alkaline. It is stratified and has evident bedding planes. Bedrock is at a depth of more than 60 inches.

Albion soils in Canadian County are mapped only with Shellabarger soils.

Bethany Series

The Bethany series consists of nearly level soils on uplands. These soils formed under a cover of grasses in material weathered from loamy and clayey sediments.

In a representative profile the surface layer is dark grayish-brown silt loam 14 inches thick. The subsoil extends to a depth of 72 inches. The upper 4 inches is dark-brown silty clay loam; the next 42 inches is dark-brown and brown silty clay; and the lower 12 inches is brown silty clay loam. The underlying material to a depth of 80 inches is yellowish-red silty clay loam.

Bethany soils are well drained. Permeability is slow, and the available water capacity is high. The water table is at a depth of more than 6 feet.

Representative profile of Bethany silt loam, 0 to 1 percent slopes, 2,600 feet south and 50 feet west of the northeast corner of sec. 11, T. 11 N., R. 8 W.

A1—0 to 14 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, granular structure; slightly hard, friable; slightly acid; clear, smooth boundary.

B1—14 to 18 inches, dark-brown (7.5YR 4/3) silty clay loam, dark brown (7.5YR 3/3) moist; strong, coarse, granular structure; hard, firm; neutral; clear, smooth boundary.

B21t—18 to 33 inches, dark-brown (7.5YR 4/2) silty clay, dark brown (7.5YR 3/2) moist; strong, medium, blocky structure; very hard, very firm; nearly continuous clay films on faces of peds; mildly alkaline; gradual, smooth boundary.

B22t—33 to 60 inches, brown (7.5YR 5/4) silty clay, dark brown (7.5YR 4/4) moist; moderate, coarse, blocky structure; very hard, very firm; nearly continuous clay films on faces of peds; few medium calcium carbonate concretions; mildly alkaline; gradual, smooth boundary.

B3—60 to 72 inches, brown (7.5YR 5/4) silty clay loam, dark brown (7.5YR 4/4) moist; common, coarse, distinct, yellowish-red (5YR 5/6) mottles; weak, coarse, blocky structure; very hard, very firm; patchy clay films on faces of peds; calcareous; mildly alkaline; gradual, smooth boundary.

C—72 to 80 inches, yellowish-red (5YR 5/6) silty clay loam, yellowish red (5YR 4/6) moist; massive; very hard, very firm; few fine gypsum crystals; calcareous; mildly alkaline.

The A1 or Ap horizon is dark grayish brown, dark brown, or brown. The B1 horizon is dark grayish brown, very dark grayish brown, dark brown, or brown. The B21t horizon is dark grayish-brown, dark-brown, or brown silty clay loam or silty clay. It is neutral or mildly alkaline. The B22t horizon is gra ish-brown, dark grayish-brown, brown, or dark-brown silty clay loam or silty clay. The B3 horizon is grayish-brown, dark grayish-brown, brown, dark-brown, yellowish-brown, dark yellowish-brown, or yellowish-red silty clay loam or silty clay. It is mildly alkaline or moderately alkaline. The C horizon is similar to the B3 horizon in color, texture, and reaction. Bedrock is at a depth of more than 60 inches.

BeA—Bethany silt loam, 0 to 1 percent slopes. This soil is nearly level. The mapped acreage includes about 5 percent Norge soils, 5 percent Pond Creek soils, and 2 percent Kirkland soils.

The soil is used mostly for alfalfa, cotton, grain sorghum, small grain, and tame pasture. A small acreage is in native grasses and is used for hay and range.

The main concern of management is maintaining soil structure and fertility. Adequate amounts of crop residue are needed. Where a large amount of crop residue is returned to the soil, additional plant nutrients are needed. The formation of a tillage pan can be prevented by changing the depth of tillage and by tilling when the soil is least compacted. Capability unit I–2; pasture and hay group 8A; Loamy Prairie range site; tree group 7.

Binger Series

The Binger series consists of very gently sloping to gently sloping soils on uplands. These soils formed under a cover of grasses in material weathered from sandstone.

In a representative profile the surface layer is reddish-brown fine sandy loam about 10 inches thick. The subsoil is red sandy clay loam about 22 inches thick. The underlying material is red, weakly cemented sandstone to a depth of 40 inches.

Binger soils are well drained. Permeability is moderate, and the available water capacity is medium. The water table is at a depth of more than 6 feet.

Representative profile of Binger fine sandy loam, 1 to 5 percent slopes, 220 feet south and 120 feet west of the northeast corner of sec. 27, T. 11 N., R. 5 W.

Ap—0 to 10 inches, reddish-brown (2.5YR 4/4) fine sandy loam, dark reddish brown (2.5YR 3/4) moist; weak, fine, granular structure; slightly hard, very friable; many fine roots; neutral; clear, smooth boundary.

B2t—10 to 32 inches, red (2.5YR 4/6) sandy clay loam, dark red (2.5YR 3/6) moist; weak, medium, prismatic structure parting to weak, fine, subangular blocky; hard, friable; many fine roots; clay films on faces of peds; neutral; clear, wavy boundary.

C—32 to 40 inches, red (2.5YR 5/6), weakly cemented sandstone; mildly alkaline.

Depth to sandstone ranges from 26 to 38 inches. The A1 or Ap horizon is reddish brown or red. The B2t horizon is reddish-brown or red sandy clay loam or fine sandy loam. The C horizon is weak-red or red sandstone that is rippable.

BnC—Binger fine sandy loam, 1 to 5 percent slopes. This soil is very gently sloping to gently sloping. It has the profile described as representative of the series. The mapping unit is about 8 percent included areas of Nash soils and spots of Quinlan soils and 15 percent areas of soils that are similar to this Binger soil but have a surface layer of loamy fine sand.

The soil is used for cotton, grain sorghum, small grain, tame pasture, peanuts, native grasses, range, and hay.

The main concerns of management are controlling soil blowing and erosion and maintaining soil structure and fertility. Leaving an adequate amount of crop residue on the surface at crop seeding time reduces the hazard of soil blowing and permits wider spacing between terraces used to control erosion. Where a large amount of crop residue is returned to the soil or left on the soil surface, additional plant nutrients are needed. Capability unit IIIe–3; pasture and hay group 8A; Sandy Prairie range site; tree group 7.

Brewer Series

The Brewer series consists of nearly level soils on flood plains. These soils formed under a cover of grasses in material weathered from loamy sediments.

In a representative profile the surface layer is very dark grayish-brown silty clay loam 12 inches thick. The upper 16 inches of the subsoil is very dark grayish-brown silty clay loam; the next 36 inches is dark-brown and brown silty clay loam; and the lower 20 inches is reddish-brown silty clay loam.

Brewer soils are moderately well drained. Permeability is slow, and the available water capacity is high. The water table is at a depth of more than 6 feet.

Representative profile of Brewer silty clay loam, 1,500 feet west and 800 feet north of the southeast corner of sec. 27, T. 13 N., R. 8 W.

A1—0 to 12 inches, very dark grayish-brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) moist; moderate, medium, granular structure; hard, friable; neutral; gradual, smooth boundary.

B21t—12 to 28 inches, very dark grayish-brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) moist; moderate, medium, subangular blocky structure; very hard, firm; nearly continuous clay films on faces of peds; mildly alkaline; gradual, smooth boundary.

B22t—28 to 48 inches, dark-brown (7.5YR 4/2) silty clay loam, dark brown (7.5YR 3/2) moist; moderate, medium, blocky structure; very hard, very firm; nearly continuous clay films on faces of peds; mildly alkaline; gradual, smooth boundary.

B23t—48 to 64 inches, brown (7.5YR 5/4) silty clay loam, dark brown (7.5YR 4/4) moist; moderate, medium, subangular blocky structure; very hard, very firm; patchy clay films on faces of peds; common, fine, soft masses of secondary carbonates; calcareous; moderately alkaline; gradual, smooth boundary.

B3—64 to 84 inches, reddish-brown (5YR 5/4) silty clay loam, reddish brown (5YR 4/4) moist; weak, medium, subangular blocky structure; very hard, firm; common, fine, soft masses of secondary carbonates; calcareous; moderately alkaline.

The A1 or Ap horizon is very dark grayish-brown, dark grayish-brown, grayish-brown, or brown silt loam or silty clay loam. It is slightly acid or neutral. The B21t horizon is very dark grayish-brown, dark grayish-brown, grayish-brown, dark-brown, or brown silty clay or silty clay loam. It ranges from slightly acid to mildly alkaline. The B22t horizon is dark brown, brown, dark grayish brown, very dark grayish brown, or grayish brown. The B23t horizon is dark brown, brown, dark reddish brown, or reddish brown. The B22t and B23t horizons are silty clay or silty clay loam that is neutral to moderately alkaline. The B3 horizon is reddish-brown, brown, or dark yellowish-brown silty clay loam or silt loam. It is mildly alkaline or moderately alkaline. Bedrock is at a depth of more than 60 inches.

Br—Brewer silty clay loam. This soil is nearly level and is rarely subject to flooding. It has the profile described as representative of the series. Included in mapping are Dale soils that make up about 5 percent of the acreage and Watonga soils that make up about 3 percent.

This soil is used mainly for alfalfa, cotton, grain sorghum, small grain, and tame pasture.

The main concern of management is maintaining soil structure and fertility. Both structure and fertility can be improved by returning adequate amounts of crop residue and plant nutrients to the soil annually. Changing the depth of tillage and tilling when the soil is least compacted prevent the formation of a tillage pan. Capability unit I–1; pasture and hay group 2A; Heavy Bottomland range site; tree group 4.

Bu—Brewer-Drummond complex. This mapping unit consists of nearly level soils that are rarely subject to flooding. The Brewer soil is in the slightly higher areas, and the Drummond soil is in slight depressions. These soils have profiles similar to those described as representative of the Brewer and Drummond series, but in places the surface layer of the Brewer soil is silt loam and the surface layer of the Drummond soil is loam. The mapping unit is about 60 percent Brewer soils, 20 percent Drummond soils, and 20 percent soils that are similar to Brewer soils but are less clayey.

This mapping unit is used mainly for grain sorghum, small grain, cotton, tame pasture, and native grasses.

The chief management concerns are maintaining soil structure and fertility and reducing surface crusting. Plant nutrients and adequate amounts of crop residue are needed. Capability unit IIIs–2; tree group 4; Brewer soil in pasture and hay group 2A and Heavy Bottomland range site; Drummond soil in pasture and hay group 2C and Saline Subirrigated range site.

Canadian Series

The Canadian series consists of nearly level soils on flood plains. These soils formed under a cover of grasses in material weathered from loamy sediments.

In a representative profile the surface layer is brown fine sandy loam about 15 inches thick. The subsoil, about 11 inches thick, is pale-brown fine sandy loam. The underlying material is pale-brown fine sandy loam to a depth of 60 inches.

Canadian soils are well drained. Permeability is moderately rapid, and the available water capacity is medium. The water table is at a depth of more than 6 feet.

Representative profile of Canadian fine sandy loam, 2,600 feet east and 200 feet south of the northwest corner of sec. 13, T. 13 N., R. 9 W.

A1—0 to 15 inches, brown (10YR 5/3) fine sandy loam, dark brown (10YR 3/3) moist; weak, fine, granular structure; slightly hard, friable; neutral; gradual, smooth boundary.

B2—15 to 26 inches, pale-brown (10YR 6/3) fine sandy loam, dark brown (10YR 4/3) moist; weak, fine, granular structure; slightly hard, friable; moderately alkaline; diffuse, smooth boundary.

C—26 to 60 inches, pale-brown (10YR 6/3) fine sandy loam, dark brown (10YR 4/3) moist; massive; slightly hard, friable; moderately alkaline.

The A1 or Ap horizon is brown, dark brown, grayish brown, or dark grayish brown. The B2 horizon is pale brown, light brown, brown, light yellowish brown, or yellowish brown. It is mildly alkaline or moderately alkaline. The C horizon is pale brown, light brown, brown, strong brown, reddish yellow, very pale brown, light yellowish brown, or yellowish brown. Bedrock is at a depth of more than 60 inches.

Ca—Canadian fine sandy loam. This soil is nearly level and is rarely subject to flooding. It has the profile described as representative of the series. Included in mapping are Dale soils that make up about 10 percent of the acreage, Minco soils 5 percent, and Yahola soils 5 percent.

This soil is used mostly for alfalfa, cotton, grain sorghum, peanuts, small grain, and tame pasture.

The main concern of management is maintaining soil structure and fertility. Where adequate amounts of crop residue and plant nutrients are returned to the soil, soil structure and fertility are improved. The formation of a tillage pan can be prevented by changing the depth of tillage and by tilling when the soil is least compacted. Capability unit I–1; pasture and hay group 2A; Loamy Bottomland range site; tree group 2.

Dale Series

The Dale series consists of nearly level soils on flood plains. These soils formed under a cover of grasses in material weathered from loamy sediments.

In a representative profile the surface layer is dark grayish-brown silt loam about 15 inches thick. The upper 9 inches of the subsoil is dark-brown silt loam; the next 18 inches is pale-brown silt loam; and the lower 22 inches is dark grayish-brown silty clay loam.

Dale soils are well drained. Permeability is moderate, and the available water capacity is high. The water table is at a depth of more than 6 feet.

Representative profile of Dale silt loam, 360 feet west and 1,060 feet south of the northeast corner of sec. 28, T. 13 N., R. 8 W.

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak, fine, granular structure; slightly hard, friable; slightly acid; abrupt, smooth boundary.

A1—7 to 15 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, granular structure; slightly hard, friable; slightly acid; clear, smooth boundary.

B21—15 to 24 inches, dark-brown (10YR 4/3) silt loam, dark brown (10YR 3/3) moist; moderate, fine, subangular blocky structure; hard, friable; neutral; gradual, smooth boundary.

B22—24 to 42 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; moderate, medium, granular structure; hard, friable; few films of secondary carbonates in lower few inches; calcareous; moderately alkaline; gradual, smooth boundary.

IIB2—42 to 64 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, subangular blocky structure; very hard; few films of secondary carbonates; calcareous; moderately alkaline.

The Ap, A1, and B21 horizons are dark grayish brown, very dark grayish brown, brown, or dark brown. The B22 horizon is pale brown, brown, dark brown, dark grayish brown, very dark grayish brown, yellowish brown, or dark yellowish brown. The IIB2 horizon is dark grayish-brown, grayish-brown, dark-brown, or brown silty clay loam or silt loam. In some areas there is a C horizon, but no IIB2 horizon. The C horizon is similar to the B22 horizon in color and texture. Bedrock is at a depth of more than 60 inches.

Da—Dale silt loam. This soil is nearly level. It is rarely subject to flooding. About 7 percent of the mapping unit is included areas of Canadian soils and spots of other Dale soils and of Brewer soils.

The soil is used mostly for alfalfa (fig. 2), cotton, grain sorghum, small grain, and tame pasture.

The main concern of management is maintaining soil structure and fertility. Where adequate amounts of crop residue and plant nutrients are returned to the soil, soil structure and fertility are improved. The formation of a tillage pan can be prevented by changing the depth of tillage and by tilling when the soil is least compacted. Capability unit I–1; pasture and hay group 2A; Loamy Bottomland range site; tree group 3.

Darnell Series

The Darnell series consists of very gently sloping to steep soils on uplands. These soils formed under a cover of trees and grasses in material weathered from sandstone.

In a representative profile the surface layer is reddish-brown fine sandy loam about 5 inches thick. The subsoil, about 6 inches thick, is reddish-brown fine sandy loam. The underlying material is red sandstone to a depth of 15 inches.

Darnell soils are somewhat excessively drained. Permeability is moderately rapid, and the available water capacity is low. The water table is at a depth of more than 6 feet.

Representative profile of Darnell fine sandy loam in an area of Darnell-Noble complex, 8 to 30 percent slopes, 1,800 feet south of the northeast corner of sec. 20, T. 11 N., R. 9 W.

A1—0 to 5 inches, reddish-brown (5YR 4/4) fine sandy loam, dark reddish brown (5YR 3/4) moist; weak, fine, granular structure; slightly hard, very friable; slightly acid; clear, smooth boundary.

Figure 2.—**Alfalfa harvest on Dale silt loam.**

B2—5 to 11 inches, reddish-brown (2.5YR 4/4) fine sandy loam, dark reddish brown (2.5YR 3/4) moist; weak, fine, granular structure; soft, very friable; slightly acid; clear, wavy boundary.
C—11 to 15 inches, red (2.5YR 4/6), weakly cemented sandstone; slightly acid.

Depth to bedrock ranges from 10 to 20 inches. The C horizon is red or light-red, rippable sandstone.

DnD—Darnell-Noble complex, 1 to 8 percent slopes. This mapping unit consists of very gently sloping to sloping soils. The Darnell soil is on crests and side slopes between areas of the Noble soil. The mapping unit is about 76 percent Darnell soils, 16 percent Noble soils, and 4 percent each of the included Grandfield and Dill soils.

This mapping unit is used mostly for oak trees and native grasses.

The main concerns of management are controlling soil blowing and erosion and keeping the grasses growing vigorously. Management practices suitable for areas used for range and tame pasture are suggested in the section "Range." Capability unit VIe–3; tree group 8; Darnell soil in pasture and hay group 14A and Shallow Savannah range site; Noble soil in pasture and hay group 8A and Sandy Savannah range site.

DnF—Darnell-Noble complex, 8 to 30 percent slopes. This mapping unit consists of strongly sloping to steep soils. The Darnell soil is on crests and side slopes between areas of the Noble soil. The Darnell soil has the profile described as representative of the Darnell series. The mapping unit is about 66 percent Darnell soils and 15 percent Noble soils. The rest is 7 percent Grandfield soils, 5 percent Quinlan soils, 4 percent Yahola soils, 2 percent Minco soils, and 1 percent Dill soils and a trace of Rock outcrop.

This mapping unit is used mostly for trees and native grasses.

The main concerns of management are controlling erosion and keeping the grasses growing vigorously. Management practices suitable for areas used for range are suggested in the section "Range." Capability unit VIIe–2; tree group 8; Darnell soil in Shallow Savannah range site, and Noble soil in Sandy Savannah range site; pasture and hay group not assigned.

Dill Series

The Dill series consists of sloping to strongly sloping soils on uplands. These soils formed under a cover of grasses in material weathered from sandstone.

In a representative profile the surface layer is reddish-brown fine sandy loam about 12 inches thick. The subsoil is red fine sandy loam about 22 inches thick. The underlying material is red, weakly cemented sandstone to a depth of 42 inches.

Dill soils are well drained. Permeability is moderately rapid, and the available water capacity is medium. The water table is at a depth of more than 6 feet.

Representative profile of Dill fine sandy loam in an area of Dill-Quinlan complex, 5 to 8 percent slopes, 1,600 feet west and 100 feet north of the southeast corner of sec. 22, T. 13 N., R. 10 W.

Ap—0 to 6 inches, reddish-brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; weak, fine, granular structure; slightly hard, very friable; neutral; abrupt, smooth boundary.
A1—6 to 12 inches, reddish-brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; weak, fine, granular structure; slightly hard, very friable; neutral; gradual, smooth boundary.
B2—12 to 34 inches, red (2.5YR 4/6) fine sandy loam, dark red (2.5YR 3/6) moist; moderate, fine, granular structure; slightly hard, friable; mildly alkaline; gradual, smooth boundary.
C—34 to 42 inches, red (2.5YR 5/6), weakly cemented sandstone; mildly alkaline.

Depth to bedrock ranges from 20 to 40 inches. The Ap or A1 horizon is reddish brown or yellowish red. The B2 horizon is red or yellowish red. The C horizon is sandstone that is rippable.

DuD—Dill-Quinlan complex, 5 to 8 percent slopes. This mapping unit consists of sloping soils. The Dill soil is on side slopes between areas of the Quinlan soil. The Dill soil has the profile described as representative of the Dill series. The Quinlan soil has a profile similar to the one described as representative of the Quinlan series, but the surface layer and subsoil are loam, fine sandy loam, or very fine sandy loam.

The mapping unit is about 56 percent Dill soils, 21 percent Quinlan soils, 11 percent Grant soils, 8 percent soils that are similar to Grant soils but have a thinner surface layer, 4 percent soils that are similar to Quinlan soils but are less than 10 inches deep over sandstone, and a trace of Rock outcrop.

The mapping unit is used mostly for native grasses. Some areas are used for small grain and tame pasture.

The main concern of management is to keep the grasses growing vigorously. In cultivated areas the main concerns are controlling soil blowing and erosion and maintaining soil structure and fertility. Returning crop residue to the soil and adding plant nutrients are good management practices. Terraces that have protected outlets, contour farming, and minimum tillage are needed. Management practices suitable for areas used for range and tame pasture are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." Capability unit IVe–5; tree group 8; Dill soil in pasture and hay group 8A and Sandy Prairie range site; Quinlan soil in pasture and hay group 14A and Shallow Prairie range site.

Drummond Series

The Drummond series consists of nearly level soils on flood plains. These soils formed under a cover of grasses in material weathered from loamy sediments.

In a representative profile the surface layer is dark grayish-brown silt loam about 10 inches thick. The subsoil extends to a depth of 42 inches. The upper 20 inches is grayish-brown silty clay loam that has a high content of sodium, and the lower 12 inches is grayish-brown clay loam. The underlying material is light-brown and pale-brown clay loam to a depth of 62 inches.

Drummond soils are somewhat poorly drained. Permeability is very slow, and the available water capacity is medium. The water table is at a depth of 4 to 10 feet in spring and winter.

Representative profile of Drummond silt loam in an area of Brewer-Drummond complex, 1,500 feet north and 100 feet east of the southwest corner of sec. 19, T. 14 N., R. 9 W.

Ap—0 to 10 inches, dark grayish-brown (10YR 4/2) silt loam; very dark grayish brown (10YR 3/2) moist; massive,

weak, fine, granular structure; hard, friable; upper ½ inch is a vesicular crust; calcareous; moderately alkaline; clear, wavy boundary.

B21t—10 to 24 inches, grayish-brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, fine and medium, subangular blocky structure; hard, firm; nearly continuous clay films on faces of peds; more than 15 percent exchangeable sodium; calcareous; moderately alkaline; gradual, smooth boundary.

B22t—24 to 30 inches, grayish-brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) moist; few, fine, distinct, light-brown mottles; moderate, medium, subangular blocky structure; very hard, very firm; nearly continuous clay films on faces of peds; few fine concretions of calcium carbonate; more than 15 percent exchangeable sodium; calcareous; moderately alkaline; gradual, smooth boundary.

B3—30 to 42 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) moist; few, fine, distinct, light-brown and dark reddish-brown mottles; weak, fine and medium, subangular blocky structure; very hard, very firm; common films and soft masses of secondary carbonates; calcareous; moderately alkaline; gradual, smooth boundary.

C1—42 to 52 inches, light-brown (7.5YR 6/4) clay loam, brown (7.5YR 5/4) moist; few, fine, distinct, dark reddish-brown mottles; massive; hard, firm; common films and fine soft masses of secondary carbonates; few fine concretions of calcium carbonate; calcareous; moderately alkaline; gradual, smooth boundary.

C2—52 to 62 inches, pale-brown (10YR 6/3) clay loam, brown (10YR 5/3) moist; few, fine, faint, light-brown mottles and few, fine, distinct, dark reddish-brown mottles; massive; hard, firm; this horizon contains coarser sand than the C1 horizon; common films and fine soft masses of secondary carbonates; few fine concretions of calcium carbonate; calcareous; moderately alkaline.

The Ap, A1, B2t, and B3 horizons are dark grayish brown, grayish brown, dark brown, brown, dark yellowish brown, or yellowish brown. The Ap, A1, and B2t horizons are mildly alkaline or moderately alkaline. The Ap or A1 horizon is silt loam or loam. The B2t horizon ranges from 15 to 18 percent in content of exchangeable sodium. The B22t, B3, and C horizons are mottled in shades of brown. The B3 horizon is clay loam, silty clay loam, or loam. In some areas the C horizon is thinly stratified with sandy loam to clay loam below a depth of 50 inches. Bedrock is at a depth of more than 60 inches.

The Drummond soils in Canadian County are mapped only with Brewer soils.

Gracemore Series

The Gracemore series consists of nearly level soils on flood plains. These soils formed under a cover of grasses in material weathered from loamy and sandy sediments.

In a representative profile the surface layer is brown loamy fine sand about 12 inches thick. The underlying material is pink fine sand that is thinly stratified with dark-brown loam, fine sandy loam, and clay loam to a depth of 72 inches.

Gracemore soils are somewhat poorly drained. Permeability is moderately rapid above the water table, and the available water capacity is low. The water table is at a depth of ½ foot to 3 feet most of the year.

Representative profile of Gracemore loamy fine sand, occasionally flooded, 2,600 feet south and 1,000 feet west of the northeast corner of sec. 5, T. 11 N., R. 9 W.

A1—0 to 12 inches, brown (7.5YR 5/4) loamy fine sand, dark brown (7.5YR 4/4) moist; weak, fine, granular structure; soft, very friable; many fine roots; calcareous; moderately alkaline; clear, smooth boundary.

C—12 to 72 inches, pink (7.5YR 7/4) fine sand, brown (7.5YR 5/4) moist; single grained; loose, very friable; very thin to 1-inch strata of dark-brown (7.5YR 4/4) fine sandy loam, loam, and clay loam that decrease in number as depth increases; bedding planes are evident; calcareous; moderately alkaline.

The A1 or Ap horizon is dark brown, brown, very dark grayish brown, dark grayish brown, grayish brown, dark reddish brown, reddish brown, or yellowish brown. The upper 10 inches of the A1 horizon is loamy fine sand, fine sandy loam, fine sand, or clay loam; below a depth of 10 inches is loamy fine sand or fine sand. The C horizon, when moist, is brown, reddish-brown, pale-brown, yellowish-brown, or light yellowish-brown fine sand or loamy fine sand. Bedrock is at a depth of more than 60 inches.

Ga—Gracemore loamy fine sand, occasionally flooded. This soil is nearly level and is occasionally subject to flooding. It has the profile described as representative of the series. Included in mapping are areas of Yahola soils that make up about 8 percent of the acreage and small areas of a soil that is similar to Gracemore soils but has a seasonal high water table at a depth of more than 40 inches.

This soil is used mostly for alfalfa, grain sorghum, small grain, and tame pasture.

The main concerns of management are maintaining soil structure and fertility and controlling soil blowing and flooding. A moderate to large amount of residue should be returned to the soil annually. Adding plant nutrients maintains fertility at a high level. Leaving an adequate amount of crop residue on the surface at crop seeding time helps control soil blowing. Upstream flood control structures and channel improvement reduce the hazard of flooding. Capability unit IIIe–4; pasture and hay group 3B; Subirrigated range site; tree group 1.

Gb—Gracemore soils, frequently flooded. These soils are nearly level and are frequently subject to flooding. They have a profile similar to the one described as representative of the series, but the upper 10 inches ranges from fine sand to clay loam. Included in mapping are areas of Yahola soils that make up about 8 percent of the acreage and small areas of riverwash sands and sloughs.

The soils are used mostly for tame pasture and native grasses.

The main concern of management is controlling flooding and soil blowing. Adequate cover reduces the hazard of soil blowing. Upstream flood control structures and channel improvement reduce the hazard of flooding. Management practices suitable for areas of these soils used for range or tame pasture are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." Capability unit Vw–1; pasture and hay group 3B; Subirrigated range site; tree group 1.

Grandfield Series

The Grandfield series consists of very gently sloping to sloping soils on uplands. These soils formed under a cover of grasses in material weathered from loamy sediments.

In a representative profile the surface layer is brown fine sandy loam about 7 inches thick. The upper 31 inches of the subsoil is reddish-brown sandy clay loam, and the lower 22 inches is red fine sandy loam.

Grandfield soils are well drained. Permeability is moderate, and the available water capacity is medium. The water table is at a depth of more than 6 feet.

Representative profile of Grandfield fine sandy loam, 3 to 5 percent slopes, 800 feet east and 100 feet south of the northwest corner of sec. 26, T. 11 N., R. 10 W.

A1—0 to 7 inches, brown (7.5YR 4/2) fine sandy loam, dark brown (7.5YR 3/2) moist; weak, fine, granular structure; slightly hard, friable; slightly acid; gradual, smooth boundary.

B21t—7 to 20 inches, reddish-brown (5YR 4/4) sandy clay loam, dark reddish brown (5YR 3/4) moist; moderate, fine, subangular blocky structure; hard, firm; clay films on faces of peds; slightly acid; clear, smooth boundary.

B22t—20 to 38 inches, reddish-brown (5YR 4/4) sandy clay loam, dark reddish brown (5YR 3/4) moist; moderate, medium, subangular blocky structure; hard, friable; clay films on faces of peds; neutral; gradual, wavy boundary.

B3—38 to 60 inches, red (2.5YR 5/6) fine sandy loam, red (2.5YR 4/6) moist; weak, coarse, prismatic structure; slightly hard, friable; patchy clay films on faces of peds; neutral.

The A1 or Ap horizon is brown, reddish-brown, or dark-brown fine sandy loam or loamy fine sand. In some areas there is a B1 horizon of reddish-brown fine sandy loam that is slightly acid. The B2t horizon is reddish brown, yellowish red, or red. It is slightly acid or neutral. The B3 horizon is red or light red. Bedrock is at a depth of more than 60 inches.

GdB—Grandfield fine sandy loam, 1 to 3 percent slopes. This soil is very gently sloping. Included areas of Minco soils make up about 5 percent of the mapped acreage, and Darnell soils 3 percent.

The soil is used mostly for alfalfa, cotton, peanuts, grain sorghum, small grain, and tame pasture. Some areas are in native grasses and are used for range and hay.

The main concerns of management are controlling soil blowing and erosion and maintaining soil structure and fertility. Where adequate amounts of crop residue and plant nutrients are returned to the soil, erosion is controlled and soil structure and fertility are improved. Seeding crops with a deep-furrow drill at right angles to the prevailing wind also helps control soil blowing. Plant nutrients are needed. Capability unit IIe-2; pasture and hay group 8A; Sandy Prairie range site; tree group 7.

GdC—Grandfield fine sandy loam, 3 to 5 percent slopes. This soil is gently sloping. It has the profile described as representative of the series. Included in mapping are spots of Darnell and Noble soils.

The soil is used mostly for cotton, grain sorghum, peanuts, small grain, and tame pasture. Some areas are in native grasses and are used for hay and pasture.

The main concerns of management are controlling soil blowing and erosion and maintaining soil structure and fertility. Leaving an adequate amount of crop residue on the surface at crop seeding time reduces the hazard of soil blowing and permits wider spacing between terraces used to control erosion. Where a large amount of crop residue is returned to the soil or left on the soil surface, plant nutrients are needed. Capability unit IIIe–3; pasture and hay group 8A; Sandy Prairie range site; tree group 7.

GdC2—Grandfield fine sandy loam, 2 to 6 percent slopes, eroded. This eroded soil is very gently sloping to sloping. It has a profile similar to the one described as representative of the series, but the surface layer is thinner and has been mixed with the subsoil in about 40 percent of the acreage. Included in mapping are small areas of Darnell, Minco, and Noble soils.

The soil is used mostly for native grasses. It is also suitable for small grain and tame pasture.

The main concern of grass management is to keep the grasses growing vigorously. In cultivated areas the main concerns of management are controlling soil blowing and erosion and maintaining soil structure and fertility. Crop residue and plant nutrients are needed. A moderate to large amount of residue should be returned to the soil annually. Capability unit IVe–6; pasture and hay group 8A; Sandy Prairie range site; tree group 7.

GdD—Grandfield fine sandy loam, 5 to 8 percent slopes. This soil is sloping. Included in mapping are small areas of Darnell, Minco, and Noble soils.

The soil is used mostly for native grasses. It is also suited to small grain and tame pasture.

The main concern of grass management is to keep the grasses growing vigorously. In cultivated areas the main concerns of management are controlling soil blowing and erosion and maintaining soil structure and fertility. Crop residue and plant nutrients are needed. Terraces that have protected outlets, contour farming, and minimum tillage also are needed. Management practices suitable for areas used for range and tame pasture are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." Capability unit IVe–5; pasture and hay group 8A; Sandy Prairie range site; tree group 7.

GdD3—Grandfield soils, 3 to 8 percent slopes, severely eroded. These severely eroded soils are very gently sloping to sloping. They have a profile similar to the one described as representative of the series, but the surface layer is fine sandy loam or loamy fine sand, is thinner, and has been mixed with the subsoil in about 40 percent of the area.

Included with this unit in mapping, and making up about 25 percent of the acreage, are soils similar to Grandfield soils in which the surface layer is material from the subsoil or uncrossable gullies are about 20 to 60 feet wide and 50 to 200 feet apart. Also included are small areas of Minco and Noble soils.

The soils are used mostly for native grasses. They are also suited to tame pasture.

The main concerns of management are controlling soil blowing and erosion and maintaining soil structure and fertility. Management of grasses includes practices to keep the grasses growing vigorously. Suitable management is suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." Capability unit VIe–2; pasture and hay group 8F; Eroded Prairie range site; tree group 9.

Grant Series

The Grant series consists of nearly level to strongly sloping soils on uplands. These soils formed under a cover of grasses in material weathered from silty sandstone.

In a representative profile the surface layer is reddish-brown silt loam about 10 inches thick. The subsoil extends to a depth of 60 inches. The upper 8 inches is reddish-brown silt loam; the next 12 inches is reddish-brown silty clay loam; and the lower 30 inches is yellowish-red and red silt loam. The underlying material is red, weakly cemented sandstone to a depth of 64 inches.

Grant soils are well drained. Permeability is moderate and the available water capacity is high. The water table is at a depth of more than 6 feet.

Representative profile of Grant silt loam in an area of Grant-Hinkle complex, 1 to 3 percent slopes, 2,000 feet south and 500 feet west of the northeast corner of sec. 4, T. 14 N., R. 7 W.

A1—0 to 10 inches, reddish-brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) moist; weak, fine, granular structure; slightly hard, friable; neutral; gradual, smooth boundary.

B1—10 to 18 inches, reddish-brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) moist; moderate, medium, granular and subangular blocky structure; slightly hard, friable; neutral; gradual, smooth boundary.

B21t—18 to 30 inches, reddish-brown (5YR 5/4) silty clay loam, reddish brown (5YR 4/4) moist; moderate, medium, subangular blocky structure; hard, friable; clay films on faces of peds; mildly alkaline; gradual, smooth boundary.

B22t—30 to 46 inches, yellowish-red (5YR 5/6) silt loam, yellowish red (5YR 4/6) moist; moderate, medium, subangular blocky structure; hard, friable; clay films on faces of peds; mildly alkaline; gradual, smooth boundary.

B3—46 to 60 inches, red (2.5YR 5/6) silt loam, red (2.5YR 4/6) moist; weak, very fine, granular structure; slightly hard, very friable; few films of secondary carbonates; calcareous; moderately alkaline; clear, smooth boundary.

C—60 to 64 inches, red (2.5YR 5/8), weakly cemented silty sandstone, red (2.5YR 4/8) moist; calcareous; moderately alkaline.

Depth to bedrock ranges from 40 to 80 inches. The A1 or Ap horizon is brown, dark brown, or reddish brown. It is slightly acid or neutral. The B1 horizon is similar to the A1 horizon in color, texture, and reaction. The B2t horizon is reddish-brown, yellowish-red, or red silt loam or silty clay loam. It is mildly alkaline or moderately alkaline. The B3 horizon is red, yellowish-red, or reddish-brown silt loam or very fine sandy loam. It is mildly alkaline or moderately alkaline. The C horizon is reddish silty sandstone that is rippable.

GhB—Grant-Hinkle complex, 1 to 3 percent slopes. This mapping unit consists of very gently sloping soils. The Hinkle soil is in the lower areas between areas of the Grant soil. The Grant soil has the profile described as representative of the Grant series. The mapping unit is about 45 percent Grant soils, 35 percent Hinkle soils, and 20 percent soils that are similar to Grant soils but have a thinner surface layer.

This mapping unit is used mainly for wheat. It is also used for small grain, cotton, grain sorghum, tame pasture, and native grasses.

The chief management concerns are controlling erosion, maintaining soil fertility and structure, and reducing surface crusting. Most of the adapted crops can be grown year after year if the soil is well managed and crop residue is returned to it. Contour farming and terracing are needed where row crops are grown. Changing the depth of tillage and tilling when the soil is least compacted prevent the formation of a tillage pan. A moderate to large amount of residue should be returned to the soil. Capability unit IIIs–1; tree group 7; Grant soil in pasture and hay group 8A and Loamy Prairie range site; Hinkle soil in pasture and hay group 8D and Slickspot range site.

GpE—Grant-Port complex, 0 to 12 percent slopes. This mapping unit consists of nearly level to strongly sloping soils in narrow drainageways. The Grant soil is on side slopes, and the Port soil is on the floor of the drainageway. The Port soil is frequently flooded. It has a profile similar to the one described as representative of the Port series, but the surface layer is silt loam or silty clay loam.

The mapping unit is about 30 percent Grant soils that have slopes of 1 to 12 percent and 20 percent Port soils that have slopes of 0 to 1 percent. About 15 percent of the unit is soils that are similar to Port soils but the dark-colored surface layer is less than 20 inches thick. Also in the unit are 5 percent each of Kingfisher, Dill, Quinlan, and Norge soils; 2 percent Renfrow soils; 1 percent each of Kirkland, Nash, and Pond Creek soils; and 10 percent soils that are similar to the preceding soils but are less thick.

This mapping unit is used mainly for native grasses. It is also suited to tame pasture.

The chief management concern is to keep the grasses growing vigorously. Capability unit VIe–1; tree group 7; Grant soil in pasture and hay group 8A and Loamy Prairie range site; Port soil in pasture and hay group 2A and Loamy Bottomland range site.

GuD—Grant-Quinlan complex, 5 to 8 percent slopes. This mapping unit consists of sloping soils. The Quinlan soil is on crests and upper side slopes between areas of the Grant soil. The mapping unit is about 68 percent Grant soils, 16 percent Quinlan soils, 12 percent Norge soils, and 4 percent Minco soils.

The mapping unit is used mainly for wheat and native grasses. It is also suited to small grain and tame pasture.

The chief management concerns are controlling erosion and maintaining soil structure and fertility. Crop residue and plant nutrients are needed. Terraces that have protected outlets, contour farming, and minimum tillage are needed. Capability unit IVe–3; tree group 8; Grant soil in pasture and hay group 8A and Loamy Prairie range site; Quinlan soil in pasture and hay group 14A and Shallow Prairie range site.

GuD2—Grant—Quinlan complex, 3 to 8 percent slopes, eroded. This mapping unit consists of gently sloping and sloping, eroded soils. The Quinlan soil is on crests and upper side slopes between areas of the Grant soil. The Grant soil has a profile similar to the one described as representative of the series, but the surface layer is slightly thinner.

The mapping unit is about 35 percent Grant soils; 20 percent Quinlan soils; 30 percent soils that are similar to Grant soils, but the surface layer has been mixed with the subsoil through tillage or the subsoil is exposed at the surface; and 15 percent Dill soils and spots of soils that are similar to Quinlan soils but are less than 10 inches thick.

The mapping unit is used mainly for native grasses. It is also used for small grain and tame pasture.

The chief management concerns in cultivated areas are controlling erosion and maintaining soil structure and fertility. Crop residue and plant nutrients are needed. Terraces that have protected outlets, contour farming, and minimum tillage also are needed. Where a large amount of crop residue is returned to the soil, nitrogen fertilizer is needed. Capability unit IVe–4; tree group 8; Grant soil in pasture and hay group 8A and Loamy Prairie range site; Quinlan soil in pasture and hay group 14A and Shallow Prairie range site.

Hinkle Series

The Hinkle series consists of nearly level to very gently sloping soils on uplands. These soils formed under a cover of grasses in material weathered from loamy and clayey sediments.

In a representative profile the surface layer is grayish-brown silt loam about 8 inches thick. The upper 10 inches of the subsoil is dark grayish-brown silty clay that has a high content of sodium; the next 28 inches is dark-brown and light brownish-gray silty clay; and the lower 16 inches is yellowish-red silty clay.

Hinkle soils are moderately well drained. Permeability is very slow, and the available water capacity is medium. The water table is at a depth of more than 6 feet.

Representative profile of Hinkle silt loam in an area of Kirkland-Hinkle complex, 0 to 3 percent slopes, 1,350 feet east and 500 feet south of the northwest corner of sec. 34, T. 11 N., R. 7 W.

Ap—0 to 8 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; massive when dry and weak, fine and medium, granular structure moist; hard, friable; upper 1 inch is a pale-brown (10YR 6/3) vesicular crust; slightly acid; abrupt, smooth boundary.

B21t—8 to 18 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) moist; strong, fine, blocky structure; very hard, very firm; clay films on faces of peds; more than 15 percent exchangeable sodium; moderately alkaline; gradual, smooth boundary.

B22t—18 to 32 inches, dark-brown (10YR 4/3) silty clay, dark brown (10YR 3/3) moist; moderate, fine, blocky structure; very hard, very firm; clay films on faces of peds; more than 15 percent exchangeable sodium; moderately alkaline; gradual, smooth boundary.

B23t—32 to 46 inches, light brownish-gray (10YR 6/2) silty clay, dark grayish brown (10YR 4/2) moist; common, medium, distinct, strong-brown (7.5YR 5/8) mottles; moderate, fine, blocky structure; very hard, very firm; clay films on faces of peds; few, fine, black concretions; many fine gypsum crystals; few films of soft, powdery secondary carbonates; few fine concretions of calcium carbonate; more than 15 percent exchangeable sodium; calcareous; moderately alkaline; gradual, smooth boundary.

B3—46 to 62 inches, yellowish-red (5YR 4/6) silty clay, dark red (5YR 3/6) moist; common, medium and coarse, distinct, light brownish-gray (10YR 6/2) mottles; weak, fine, blocky structure; very hard, very firm; few films of secondary carbonates; calcareous; moderately alkaline.

Depth to secondary carbonates ranges from 20 to 35 inches. The Ap or A1 horizon is grayish brown, dark grayish brown, brown, dark brown, pale brown, or reddish brown. It is slightly acid or neutral. The B2t horizon is dark grayish-brown, grayish-brown, light brownish-gray, brown, dark-brown, reddish-brown, yellowish-brown, or dark yellowish-brown silty clay loam, clay loam, silty clay, or clay. It is mildly alkaline or moderately alkaline in the upper part and moderately alkaline in the lower part. The B2t horizon ranges from 15 to 20 percent in content of exchangeable sodium. The B3 horizon is yellowish red, weak red, reddish brown, light red, dark reddish gray, or reddish yellow. In some areas there is a C horizon that is similar to the B3 horizon in color, texture, and reaction. Bedrock is at a depth of more than 60 inches.

The Hinkle soils in Canadian County are mapped only with Grant and Kirkland soils.

Kingfisher Series

The Kingfisher series consists of very gently sloping and gently sloping soils on uplands. These soils formed under a cover of grasses in material weathered from sandstone and shale.

In a representative profile the surface layer is reddish-brown silt loam about 10 inches thick. The subsoil extends to a depth of 38 inches. The upper 6 inches is reddish-brown silt loam, and the lower 22 inches is reddish-brown silty clay loam. The underlying material is red sandstone and shale to a depth of 54 inches.

Kingfisher soils are well drained. Permeability is moderately slow, and the available water capacity is high. The water table is at a depth of more than 6 feet.

Representative profile of Kingfisher silt loam, 1 to 3 percent slopes, 1,950 feet east and 150 feet south of the northwest corner of sec. 22, T. 14 N., R. 7 W.

A1—0 to 10 inches, reddish-brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) moist; moderate, medium, granular structure; slightly hard, friable; common fine roots; slightly acid; gradual, smooth boundary.

B1—10 to 16 inches, reddish-brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) moist; moderate, coarse, granular structure; slightly hard, friable; common fine roots; slightly acid; gradual, smooth boundary.

B21t—16 to 28 inches, reddish-brown (5YR 4/4) silty clay loam, dark reddish brown (5YR 3/4) moist; weak, coarse, prismatic structure parting to moderate, medium, subangular blocky; hard, firm; few fine roots; clay films on faces of peds; neutral; gradual, smooth boundary.

B22t—28 to 38 inches, reddish-brown (2.5YR 4/4) silty clay loam, dark reddish brown (2.5YR 3/4) moist; weak, coarse, prismatic structure parting to moderate, medium, subangular blocky; hard, firm; patchy clay films on faces of peds; neutral; gradual, smooth boundary.

C—38 to 54 inches, red (2.5YR 5/8) partly weathered sandstone and shale.

Depth to sandstone and shale ranges from 26 to 40 inches. The B1 horizon is silt loam or silty clay loam that is slightly acid or neutral. The B2t horizon is red or reddish brown. It is neutral or mildly alkaline in the upper part and neutral to moderately alkaline in the lower part. The C horizon is partly weathered sandstone and shale that is rippable.

KfB—Kingfisher silt loam, 1 to 3 percent slopes. This soil is very gently sloping. It has the profile described as representative of the series. Included in mapping are areas of Norge soils that make up about 7 percent of the acreage, areas of Renfrow soils that make up 5 percent, and spots of Hinkle soils.

The soil is used mostly for cotton, grain sorghum, small grain, alfalfa, and tame pasture. A small acreage is in native grasses and is used for range and hay.

The main concerns of management are controlling erosion and maintaining soil structure and fertility. Leaving crop residue on the surface helps control erosion. Terracing is needed in some areas where no residue is maintained on the surface. Where a large amount of crop residue is returned to the soil, plant nutrients are needed. Changing the depth of tillage and tilling when the soil is least compacted prevent the formation of a tillage pan. Capability unit IIe–1; pasture and hay group 8A; Loamy Prairie range site; tree group 7.

KfC—Kingfisher silt loam, 3 to 5 percent slopes. This soil is gently sloping. Included in mapping are spots of Norge, Renfrow, and Vernon soils.

This soil is used for cotton, grain sorghum, small grain, tame pasture, and native grasses.

The main concerns of management are controlling erosion and maintaining soil fertility and structure. Terracing and contour farming are needed to reduce runoff and erosion. Terraces can be spaced farther apart if adequate conservation practices are applied. Plant nutrients are needed where large amounts of crop residue are returned to the soil or left on the surface. Leaving crop residue on the surface at crop seeding time helps control erosion. Capability unit IIIe–2; pasture and hay group 8A; Loamy Prairie range site; tree group 7.

Kirkland Series

The Kirkland series consists of nearly level to very gently sloping soils on uplands. These soils formed under a cover of grasses in material weathered from shale or clayey sediments.

In a representative profile the surface layer is dark grayish-brown silt loam about 10 inches thick. The upper 24 inches of the subsoil is dark grayish-brown clay; the next 30 inches is dark yellowish-brown clay; and the lower 16 inches is yellowish-red clay.

Kirkland soils are well drained. Permeability is very slow, and the available water capacity is high. The water table is at a depth of more than 6 feet.

Representative profile of Kirkland silt loam, 0 to 1 percent slopes, 2,000 feet west and 150 feet north of the southeast corner of sec. 30, T. 12 N., R. 7 W.

A1—0 to 10 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, granular structure; slightly hard, friable; slightly acid; abrupt, smooth boundary.

B21t—10 to 26 inches, dark grayish-brown (10YR 4/2) clay, very dark grayish brown (10YR 3/2) moist; moderate, medium, blocky structure; very hard, very firm; nearly continuous clay films on faces of peds; neutral; gradual, smooth boundary.

B22t—26 to 34 inches, dark grayish-brown (10YR 4/2) clay, very dark grayish brown (10YR 3/2) moist; moderate, medium, blocky structure; very hard, very firm; nearly continuous clay films on faces of peds; neutral; gradual, smooth boundary.

B23tca—34 to 64 inches, dark yellowish-brown (10YR 4/4) clay, dark yellowish brown (10YR 3/4) moist; weak, medium and coarse, blocky structure; very hard, very firm; patchy clay films on faces of peds; common fine and medium concretions of calcium carbonate; calcareous; moderately alkaline; gradual, smooth boundary.

B3—64 to 80 inches, yellowish-red (5YR 5/6) clay, yellowish red (5YR 4/6) moist; common, fine, faint, yellowish-red mottles; weak, coarse, blocky structure; very hard, very firm; patchy clay films on faces of peds; common fine white crystals, probably of gypsum; calcareous; moderately alkaline.

The A1 or Ap horizon is brown, dark brown, dark grayish brown, or very dark grayish brown. It is slightly acid or neutral. The B21t and B22t horizons are brown, dark brown, grayish brown, dark grayish brown, or reddish brown. The B23tca horizon is brown, dark brown, yellowish brown, dark yellowish brown, reddish brown, yellowish red, or red. It is mildly alkaline or moderately alkaline. The B3 horizon is yellowish red or red. It is mildly alkaline or moderately alkaline. Bedrock is at a depth of more than 60 inches.

KrA—Kirkland silt loam, 0 to 1 percent slopes. This soil is nearly level. It has the profile described as representative of the series. Included areas of Bethany soils make up about 7 percent of the mapped acreage, and Norge soils 3 percent.

The soil is used mostly for cotton, grain sorghum, small grain, and tame pasture. A small acreage is in native grasses and is used for range and hay.

The main concerns of management are controlling erosion and maintaining soil structure and fertility. Crop residue is needed to maintain soil structure and fertility. Where large amounts of crop residue are returned to the soil, plant nutrients are needed. Changing the depth of tillage and tilling when the soil is least compacted prevent the formation of a tillage pan. Capability unit IIs–1; pasture and hay group 8C; Claypan Prairie range site; tree group 5.

KrB—Kirkland silt loam, 1 to 3 percent slopes. This soil is very gently sloping. About 3 percent of the mapping unit is included areas of Pond Creek soils, and 10 percent is Renfrow soils.

The soil is used mostly for cotton, grain sorghum, small grain, and tame pasture. A small acreage is in native grass and is used for range and hay.

The main concerns of management are controlling erosion and maintaining soil fertility and structure. Most of the adapted crops can be grown year after year if the soil is well managed and crop residue is returned to it. Contour farming and terracing are needed where row crops are grown. Changing the depth of tillage and tilling when the soil is least compacted prevent the formation of a tillage pan. Capability unit IIIe–1; pasture and hay group 8C; Claypan Prairie range site; tree group 5.

KsB—Kirkland-Hinkle complex, 0 to 3 percent slopes. This mapping unit consists of nearly level and very gently sloping soils. The Hinkle soil is in slight depressions between areas of the Kirkland soil. The mapping unit is about 50 percent Kirkland soils, 35 percent Hinkle soils, and 15 percent included soils that are similar to Kirkland soil but have a thinner surface layer.

This mapping unit is used mostly for wheat. It is also used for small grain, grain sorghum, tame pasture, and native grasses.

The main concerns of management are controlling erosion, maintaining soil fertility and structure, and reducing surface crusting. Returning crop residue to the soil and adding plant nutrients are good management practices. Changing the depth of tillage and tilling when the soil is least compacted prevent the formation of a tillage pan. Management practices suitable for areas used for range and tame pasture are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." Capability unit IVs–1; tree group 5; Kirkland soil in pasture and hay group 8C and Claypan Prairie range site; Hinkle soil in pasture and hay group 8D and Slickspot range site.

Konawa Series

The Konawa series consists of gently sloping and sloping soils on uplands. These soils formed under a cover of trees and grasses in material weathered from loamy sediments.

In a representative profile the surface layer is grayish-brown loamy fine sand about 6 inches thick. The subsurface layer is pale-brown loamy fine sand about 10 inches thick. The subsoil extends to a depth of 52 inches. The upper 20 inches is yellowish-red sandy clay loam, and the lower 16 inches is yellowish-red fine sandy loam. The underlying material is yellowish-red fine sandy loam to a depth of 70 inches.

Konawa soils are well drained. Permeability is moderate, and the available water capacity is medium. The water table is at a depth of more than 6 feet.

Representative profile of Konawa loamy fine sand, 3 to 8 percent slopes, 2,000 feet east and 150 feet south of the northwest corner of sec. 2, T. 14 N., R. 10 W.

A1—0 to 6 inches, grayish-brown (10YR 5/2) loamy fine sand, very dark grayish brown (10YR 3/2) moist; weak, fine, granular structure; soft, very friable; few fine roots; slightly acid; clear, smooth boundary.

A2—6 to 16 inches, pale-brown (10YR 6/3) loamy fine sand, dark brown (10YR 4/3) moist; structureless; loose; few fine roots; medium acid; clear, wavy boundary.

B2t— 16 to 36 inches, yellowish-red (5YR 4/6) sandy clay loam, yellowish red (5YR 3/6) moist; weak, coarse, prismatic structure parting to weak, medium, subangular blocky; hard, firm; clay films on faces of peds and bridging sand grains; few fine roots; medium acid; gradual, smooth boundary.

B3—36 to 52 inches, yellowish-red (5YR 5/6) fine sandy loam, yellowish red (5YR 4/6) moist; weak, coarse, prismatic structure parting to weak, fine, granular; hard, friable; patchy clay films on faces of peds; medium acid; gradual, smooth boundary.

C—52 to 70 inches, yellowish-red (5YR 5/6) fine sandy loam, yellowish red (5YR 4/6) moist; structureless; hard, friable; slightly acid.

The A1 or Ap horizon is brown, dark brown, grayish brown, dark grayish brown, yellowish brown, or dark yellowish brown. The A2 horizon is pale brown, light brown, brown, very pale brown, yellowish brown, or light yellowish brown. The B2t horizon is yellowish red, red, or reddish brown. The B3 and C horizons are yellowish-red, reddish-yellow, or red fine sandy loam or loamy fine sand. Bedrock is at a depth of more than 60 inches.

KwD—Konawa loamy fine sand, 3 to 8 percent slopes. This soil is gently sloping and sloping. Included areas of Shellabarger soils make up about 10 percent of the mapped acreage.

This soil is used mostly for alfalfa, cotton, grain sorghum, small grain, peanuts, tame pasture, and native grasses.

The main concerns of management are controlling soil blowing and erosion and maintaining soil structure and fertility. Leaving crop residue on the surface at crop seeding time reduces soil blowing. Terracing and contour farming are needed where row crops are grown. Plant nutrients are needed where large amounts of crop residue are returned to the soil or left on the surface. The natural fertility of the soil is low, and plant nutrients are needed for crops and tame pasture. Management practices suitable for areas of these soils used for range and tame pasture are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." Capability unit IVe–2; pasture and hay group 9A; Deep Sand Savannah range site; tree group 7.

McLain Series

The McLain series consists of nearly level soils on flood plains. These soils formed under a cover of grasses in material weathered from loamy sediments.

In a representative profile the surface layer is dark-brown silty clay loam about 14 inches thick. The subsoil is reddish-brown silty clay loam to a depth of 64 inches.

McLain soils are moderately well drained. Permeability is slow, and the available water capacity is high. The water table is at a depth of more than 6 feet.

Representative profile of McLain silty clay loam, 2,000 feet south and 200 feet west of the northeast corner of sec. 3, T. 10 N., R. 7 W.

Ap—0 to 8 inches, dark-brown (7.5YR 4/2) silty clay loam, dark brown (7.5YR 3/2) moist; weak, fine, granular structure; hard, firm; neutral; abrupt, smooth boundary.

A1—8 to 14 inches, dark-brown (7.5YR 4/2) silty clay loam, dark brown (7.5YR 3/2) moist; moderate, medium, granular structure; hard, firm; mildly alkaline; gradual smooth boundary.

B21t—14 to 29 inches, reddish-brown (5YR 4/3) silty clay loam, dark reddish brown (5YR 3/3) moist; moderate, medium, blocky structure; very hard, very firm; nearly continuous clay films on faces of peds; mildly alkaline; gradual, smooth boundary.

B22t—29 to 44 inches, reddish-brown (5YR 4/4) silty clay loam, dark reddish brown (5YR 3/4) moist; weak, medium, subangular blocky structure; very hard, very firm; patchy clay films on faces of peds; moderately alkaline; gradual, smooth boundary.

B3—44 to 64 inches, reddish-brown (5YR 5/4) silty clay loam, reddish brown (5YR 4/4) moist; weak, fine, subangular blocky structure parting to moderate, medium, granular; hard, firm; few, fine, soft masses and films of powdery secondary carbonates; calcareous; moderately alkaline.

The Ap or A1 horizon is brown, dark brown, or reddish brown. It is neutral or mildly alkaline. The B21t horizon is reddish-brown or dark reddish-gray silty clay loam or silty clay. The B22t and B3 horizons are silty clay loam or silty clay. The B2t horizon is mildly alkaline or moderately alkaline. Bedrock is at a depth of more than 60 inches.

Mc—McLain silty clay loam. This soil is nearly level. It is rarely subject to flooding. About 5 percent of the mapping unit is included areas of Dale soils and 3 percent is Watonga soils.

The soil is used mostly for alfalfa, cotton, grain sorghum, small grain, and tame pasture.

The main concern of management is maintaining soil structure and fertility. Where adequate amounts of crop residue and plant nutrients are returned to the soil, soil structure and fertility are improved. Changing the depth of tillage and tilling when the soil is least compacted prevent the formation of a tillage pan. Capability unit I–1; pasture and hay group 2A; Heavy Bottomland range site; tree group 4.

Minco Series

The Minco series consists of very gently sloping to steep soils on uplands. These soils formed under a cover of grasses in material weathered from loamy sediments.

In a representative profile the surface layer is dark-brown silt loam about 12 inches thick. The subsoil extends to a depth of 50 inches. The upper 16 inches is brown silt loam, and the lower 22 inches is reddish-brown silt loam. The underlying material is yellowish-red silt loam to a depth of 72 inches.

Minco soils are well drained. Permeability is moderate, and the available water capacity is high. The water table is at a depth of more than 6 feet.

Representative profile of Minco silt loam, 3 to 5 percent slopes, 800 feet south and 600 feet west of the northeast corner of sec. 13, T. 11 N., R. 10 W.

A1—0 to 12 inches, dark-brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; moderate, fine, granular structure; hard, friable; many fine roots; slightly acid; diffuse, smooth boundary.

B21—12 to 28 inches, brown (7.5YR 5/4) silt loam, dark brown (7.5YR 4/4) moist; weak, coarse, prismatic structure parting to weak, fine, granular; hard, friable; many fine roots; neutral; gradual, smooth boundary.

B22—28 to 50 inches, reddish-brown (5YR 5/4) silt loam, reddish brown (5YR 4/4) moist; weak, coarse, prismatic structure; hard, friable; few fine roots; mildly alkaline; gradual, smooth boundary.

C—50 to 72 inches, yellowish-red (5YR 5/6) silt loam, yellowish red (5YR 4/6) moist; massive; hard, friable; few films of soft, powdery secondary carbonates; calcareous; moderately alkaline.

The A1 or Ap horizon is dark-brown, brown, or reddish-brown silt loam or very fine sandy loam. It is slightly acid or neutral. The B2 horizon is brown, dark-brown, reddish-brown, or yellowish-red silt loam or very fine sandy loam. The B21 horizon is neutral to moderately alkaline. The B22

horizon is mildly alkaline or moderately alkaline. The C horizon is light-brown, yellowish-red, or reddish-yellow silt loam, very fine sandy loam, or loam. Bedrock is at a depth of more than 60 inches.

MnD—Minco very fine sandy loam, 5 to 8 percent slopes. This soil is sloping. It has a profile similar to the one described as representative of the series, but it is very fine sandy loam throughout. The mapping unit is about 5 percent included areas of soils that are similar to Minco soils but have a surface layer of fine sandy loam and 5 percent areas of Grandfield soils.

This soil is used mostly for small grain, tame pasture, and native grasses.

The main concerns of management are controlling soil blowing and erosion and maintaining soil structure and fertility. Leaving crop residue on the surface at crop seeding time reduces the hazard of erosion. If crop residue is not returned to the soil, terracing and contour farming are needed to control erosion. Pasture of weeping lovegrass or bermudagrass to which adequate plant nutrients are added is productive and effectively reduces the hazard of erosion. Management practices suitable for areas used for range and tame pasture are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." Capability unit IVe–3; pasture and hay group 8A; Loamy Prairie range site; tree group 7.

MnF—Minco very fine sandy loam, 8 to 30 percent slopes. This soil is strongly sloping to steep. It has a profile similar to the one described as representative of the series, but it is very fine sandy loam throughout. About 15 percent of the mapping unit is included areas of soils that are similar to Minco soils but have a surface layer of fine sandy loam or a slightly thinner surface layer. Also included are small areas of Albion and Quinlan soils.

The soil is used mostly for native grasses.

The main concerns of management are controlling soil blowing and erosion and keeping the grasses growing vigorously. Management of areas used for range and tame pasture is suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." Capability unit VIe–4; pasture and hay group 8A; Loamy Prairie range site; tree group 7.

MsB—Minco silt loam, 1 to 3 percent slopes. This soil is very gently sloping. Included in mapping are spots of Grant and Pond Creek soils.

This soil is used mostly for alfalfa, cotton, grain sorghum, peanuts, small grain, and tame pasture. A small acreage is in native grasses and is used for range and hay.

The main concerns of management are controlling erosion and maintaining soil structure and fertility. Erosion can be controlled by leaving crop residue on the surface. Terracing is needed in some areas where no residue is maintained on the surface. Where large amounts of crop residue are returned to the soil, plant nutrients are needed. Changing the depth of tillage and tilling when the soil is least compacted prevent the formation of a tillage pan. Capability unit IIe–1; pasture and hay group 8A; Loamy Prairie range site; tree group 7.

MsC—Minco silt loam, 3 to 5 percent slopes. This soil is gently sloping. It has the profile described as representative of the series. Included in mapping are spots of Grandfield soils. About 10 percent of the mapping unit is included areas of soils that are similar to Minco soils but have a surface layer of fine sandy loam.

The soil is used for cotton, grain sorghum, small grain, peanuts, tame pasture, and native grasses.

The main concerns of management are controlling erosion and maintaining soil fertility and structure. Terracing and contour farming are needed to reduce runoff and erosion. Terraces can be spaced farther apart where adequate conservation practices are applied. Plant nutrients should be added where large amounts of crop residue are returned to the soil or left on the surface. Leaving crop residue on the surface at crop seeding time helps control erosion. Capability unit IIIe–2; pasture and hay group 8A; Loamy Prairie range site; tree group 7.

Nash Series

The Nash series consists of gently sloping and sloping soils on uplands. These soils formed under a cover of grasses in material weathered from sandstone.

In a representative profile the surface layer is reddish-brown loam about 11 inches thick. The upper 14 inches of the subsoil is reddish-brown loam, and the lower 8 inches is red loam. The underlying material is red sandstone to a depth of 40 inches.

Nash soils are well drained. Permeability is moderate, and the available water capacity is high. The water table is at a depth of more than 6 feet.

Representative profile of Nash loam in an area of Nash-Quinlan complex, 3 to 8 percent slopes, 200 feet east and 700 feet north of the southwest corner of sec. 14, T. 11 N., R. 5 W.

A1—0 to 11 inches, reddish-brown (5YR 4/3) loam, dark reddish brown (5YR 3/3) moist; moderate, fine, granular structure; hard, friable; many fine roots; slightly acid; gradual, smooth boundary.

B2—11 to 25 inches, reddish-brown (2.5YR 4/4) loam, dark reddish brown (2.5YR 3/4) moist; weak, fine, subangular blocky structure; hard, friable; many fine roots; slightly acid; gradual, smooth boundary.

B3—25 to 33 inches, red (2.5YR 4/6) loam, dark red (2.5YR 3/6) moist; weak, medium, granular structure; hard, friable; few fine roots; neutral; gradual, wavy boundary.

C—33 to 40 inches, red (2.5YR 5/6), weakly consolidated sandstone; moderately alkaline.

Depth to sandstone ranges from 20 to 40 inches. The A1 or Ap horizon is reddish-brown, reddish-gray, or dark reddish-gray loam or silt loam. It is slightly acid or neutral. The B2 horizon is reddish-brown, yellowish-red, or red loam or silt loam. It is slightly acid or neutral. The B3 horizon is red or yellowish-red loam or silt loam. It is neutral or mildly alkaline. The C horizon is sandstone that is rippable. It is mildly alkaline or moderately alkaline.

NaD—Nash-Quinlan complex, 3 to 8 percent slopes. This mapping unit consists of gently sloping to sloping soils. The Quinlan soil is on crests and microcrests of side slopes between areas of the Nash soil. The Nash soil has the profile described as representative of the Nash series, but in places the surface layer is silt loam. The Quinlan soil has a profile similar to the one described as representative of the Quinlan series, but the surface layer is fine sandy loam and very fine sandy loam. The mapping unit is about 78 percent Nash soils, 16 percent Quinlan soils, and 6 percent Kingfisher and Norge soils.

This mapping unit is used mostly for small grain, tame pasture, and native grasses.

The main concerns of management are controlling erosion and maintaining soil structure and fertility. Leaving crop residue on the surface at crop seeding time

reduces the hazard of erosion. Contour farming and terracing are needed to help control erosion. Management practices suitable for areas used for range and tame pasture are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." Capability unit IVe–3; tree group 8; Nash soil in pasture and hay group 8A and Loamy Prairie range site; Quinlan soil in pasture and hay group 14A and Shallow Prairie range site.

NaD2—Nash-Quinlan complex, 3 to 8 percent slopes, eroded. This mapping unit consists of gently sloping to sloping, eroded soils. The Quinlan soil is on crests and microcrests of side slopes between areas of the Nash soil. The Nash soil has a profile similar to the one described as representative of the Nash series, but the surface layer is loam or silt loam and is slightly thinner. The Quinlan soil has a profile similar to the one described as representative of the Quinlan series, but the surface layer is loam, fine sandy loam, or very fine sandy loam.

This mapping unit is about 35 percent Nash soils, 16 percent Quinlan soils, 28 percent soils that are similar to Nash soils but have a thinner surface layer, 16 percent soils that are similar to Quinlan soils but are less than 10 inches deep over bedrock, and 5 percent Vernon soils.

The mapping unit is used mostly for wheat and native grasses. It is also suited to small grain and tame pasture.

Management practices suitable for areas used for range and tame pasture are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." In cultivated areas the main concerns of management are controlling erosion and maintaining soil structure and fertility. Leaving crop residue on the surface at crop seeding time reduces the hazard of erosion. Contour farming and terracing are needed. Where a large amount of crop residue is returned to the soil, plant nutrients are needed. Capability unit IVe–4; tree group 8; Nash soil in pasture and hay group 8A and Loamy Prairie range site; Quinlan soil in pasture and hay group 14A and Shallow Prairie range site.

NaD3—Nash-Quinlan complex, 3 to 8 percent slopes, severely eroded. This mapping unit consists of gently sloping and sloping, severely eroded soils. The Quinlan soil is on crests and microcrests of side slopes between areas of the Nash soil. The Nash soil has a profile similar to the one described as representative of the Nash series, but the surface layer is loam or silt loam and is slightly thinner. The Quinlan soil has a profile similar to the one described as representative of the Quinlan series, but the surface layer is loam, fine sandy loam, or very fine sandy loam.

The mapping unit is about 40 percent Nash soils, 20 percent Quinlan soils, 25 percent soils that are similar to Nash soils but have a thinner surface layer or uncrossable gullies, and 15 percent soils that are similar to Quinlan soils but are less than 10 inches deep over bedrock or have uncrossable gullies. The uncrossable gullies are 5 to 15 feet wide and 50 to 300 feet apart.

This mapping unit is used for native grasses. It is also suited to tame pasture.

The main concerns of management are controlling erosion and maintaining soil structure and fertility. Management of grasses includes practices to keep them growing vigorously. Management practices suitable for areas used for range and pasture are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." Capability unit VIe–2; pasture and hay group 8F; Eroded Prairie range site; tree group 9.

Noble Series

The Noble series consists of very gently sloping to steep soils on uplands. These soils formed under a cover of trees and grasses in material weathered from loamy sediments.

In a representative profile the surface layer is reddish-brown fine sandy loam about 10 inches thick. The upper 10 inches of the subsoil is reddish-brown fine sandy loam, and the lower 40 inches is red fine sandy loam.

Noble soils are well drained. Permeability is moderately rapid, and the available water capacity is medium. The water table is at a depth of more than 6 feet.

Representative profile of Noble fine sandy loam, 3 to 5 percent slopes, 1,600 feet east and 1,600 feet south of the northwest corner of sec. 16, T. 11 N., R. 10 W.

A1—0 to 10 inches, reddish-brown (5YR 4/3) fine sandy loam, dark reddish brown (5YR 3/3) moist; weak, fine, granular structure; slightly hard, very friable; many fine roots; slightly acid; gradual, smooth boundary.

B2—10 to 20 inches, reddish-brown (5YR 4/4) fine sandy loam, dark reddish brown (5YR 3/4) moist; weak, coarse, prismatic structure parting to weak, fine, granular; slightly hard, very friable; common fine roots; slightly acid; gradual, smooth boundary.

B3—20 to 60 inches, red (2.5YR 4/6) fine sandy loam, dark red (2.5YR 3/6) moist; weak, coarse, prismatic structure; slightly hard, very friable; few fine roots; slightly acid.

The A1 or Ap horizon is brown, dark brown, or reddish brown. The B2 horizon is reddish brown, red, or yellowish red. The B3 horizon is red or yellowish red. It is slightly acid or neutral. In some areas there is a C horizon that is similar to the B3 horizon in color, texture, and reaction. Bedrock is at a depth of more than 60 inches.

NbC—Noble fine sandy loam, 3 to 5 percent slopes. This soil is gently sloping. Included in mapping are spots of Darnell and Yahola soils and small areas of soils that are similar to Noble soils but are only 20 to 40 inches deep over bedrock.

This soil is used for cotton, grain sorghum, peanuts, small grain, tame pasture, and native grasses.

The main concerns of management are controlling soil blowing and erosion and maintaining soil structure and fertility. Leaving crop residue on the soil surface at crop seeding time reduces the hazard of soil blowing and permits wider spacing between terraces used to control erosion. Plant nutrients are needed where large amounts of crop residue are returned to the soil or are left on the surface. Capability unit IIIe–3; pasture and hay group 8A; Sandy Savannah range site; tree group 7.

Norge Series

The Norge series consists of very gently sloping to sloping soils on uplands. These soils formed under a cover of grasses in material weathered from loamy sediments.

In a representative profile the surface layer is dark-brown silt loam about 10 inches thick. The upper 5 inches of the subsoil is dark-brown silty clay loam; the next 33 inches is reddish-brown silty clay loam; and the lower 22 inches is yellowish-red silty clay loam.

Norge soils are well drained. Permeability is moderately slow, and the available water capacity is high. The water table is at a depth of more than 6 feet.

Representative profile of Norge silt loam, 1 to 3 percent slopes, 1,300 feet south and 100 feet west of the northeast corner of sec. 2, T. 12 N., R. 9 W.

A1—0 to 10 inches, dark-brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; moderate, fine, granular structure; slightly hard, friable; many fine roots; slightly acid; clear, smooth boundary.

B1—10 to 15 inches, dark-brown (7.5YR 4/2) silty clay loam, dark brown (7.5YR 3/2) moist; moderate, medium, granular structure; slightly hard, friable; common fine roots; slightly acid; gradual, smooth boundary.

B21t—15 to 35 inches, reddish-brown (5YR 4/4) silty clay loam, dark reddish brown (5YR 3/4) moist; moderate, fine, subangular blocky structure; hard, firm; few fine roots; clay films on faces of peds; neutral; gradual, smooth boundary.

B22t—35 to 48 inches, reddish-brown (5YR 5/4) silty clay loam, reddish brown (5YR 4/4) moist; few, fine, distinct, light-gray mottles and few, medium, faint, yellowish-red (5YR 5/8) mottles; moderate, medium, blocky structure; hard, firm; nearly continuous clay films on faces of peds; neutral; gradual, smooth boundary.

B23t—48 to 60 inches, yellowish-red (5YR 5/6) silty clay loam, yellowish red (5YR 4/6) moist; few, medium, distinct, light-gray (10YR 7/2) mottles and few, medium, faint, yellowish-red (5YR 5/8) mottles; moderate, medium, blocky structure; hard, firm; nearly continuous clay films on faces of peds; neutral; gradual, smooth boundary.

B24t—60 to 70 inches, yellowish-red (5YR 5/6) silty clay loam, yellowish red (5YR 4/6) moist; few, medium, distinct, light-gray (10YR 7/2) mottles and few, medium, faint, yellowish-red (5YR 5/8) mottles; weak, medium, blocky structure; very hard, very firm; nearly continuous clay films on faces of peds; mildly alkaline.

The A1 or Ap horizon is brown, dark brown, or reddish brown. The B1 horizon is brown, dark-brown, or reddish-brown silt loam or silty clay loam. The B21t and B22t horizons are reddish brown, red, or yellowish red. They are slightly acid or neutral. The B23t and B24t horizons are red or yellowish red. They are slightly acid to mildly alkaline. The lower part of the Bt horizon is mottled in shades of red and gray. Bedrock is at a depth of more than 60 inches.

NrB—Norge silt loam, 1 to 3 percent slopes. This soil is very gently sloping. It has the profile described as representative of the series. The mapping unit is about 5 percent included areas of Kingfisher soils, 5 percent areas of Renfrow soils and spots of Pond Creek and Shellabarger soils, and 5 percent areas of soils that are similar to Norge soils but have a surface layer of fine sandy loam.

This soil is used mostly for alfalfa, cotton, grain sorghum, peanuts, small grain, and tame pasture. A small acreage is in native grasses and is used for range and hay.

The main concerns of management are controlling erosion and maintaining soil structure and fertility. Erosion can be controlled by leaving crop residue on the surface. Terracing is needed in some areas where no residue is maintained on the surface. Where large amounts of crop residue (fig. 3) are returned to the soil, plant nutrients are needed. Changing the depth of tillage and tilling when the soil is least compacted prevent the formation of a tillage

Figure 3.—**Stubble mulching on Norge silt loam, 1 to 3 percent slopes.**

pan. Capability unit IIe–1; pasture and hay group 8A; Loamy Prairie range site; tree group 7.

NrC—Norge silt loam, 3 to 5 percent slopes. This soil is gently sloping. Included in mapping are areas of Kingfisher soils that make up about 3 percent of the acreage, areas of Shellabarger soils that make up 5 percent, and areas of Renfrow soils that make up 3 percent.

The soil is used for cotton, grain sorghum, small grain, tame pasture, and native grasses.

The main concerns of management are controlling erosion and maintaining soil fertility and structure. Terracing and contour farming are needed to reduce runoff and erosion. Terraces can be spaced farther apart where adequate conservation practices are used. Plant nutrients are needed where large amounts of crop residue are returned to the soil or left on the surface. Leaving crop residue on the surface at crop seeding time helps control erosion. Capability unit IIIe–2; pasture and hay group 8A; Loamy Prairie range site; tree group 7.

NrD—Norge silt loam, 5 to 8 percent slopes. This soil is sloping. Included areas of Kingfisher, Grant, and Minco soils make up about 5 percent each of the mapped acreage.

The soil is used for native grasses. It is also suited to small grain and tame pasture.

Management practices for areas used for range and tame pasture are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." In cultivated areas, the main concerns of management are controlling erosion and maintaining soil structure and fertility. Leaving crop residue on the surface at crop seeding time reduces the hazard of erosion. Contour farming and terracing are needed. Capability unit IVe–3; pasture and hay group 8A; Loamy Prairie range site; tree group 7.

Pond Creek Series

The Pond Creek series consists of nearly level and very gently sloping soils on uplands. These soils formed under a cover of grasses in material weathered from loamy sediments.

In a representative profile the surface layer is dark grayish-brown silt loam about 14 inches thick. The upper 5 inches of the subsoil is grayish-brown silty clay loam; the next 17 inches is dark-brown silty clay loam; and the lower 30 inches is brown silty clay loam.

Pond Creek soils are well drained. Permeability is moderately slow, and the available water capacity is high. The water table is at a depth of more than 6 feet.

Representative profile of Pond Creek silt loam, 0 to 1 percent slopes, 1,700 feet south and 1,700 feet west of the northeast corner of sec. 9, T. 12 N., R. 8 W.

Ap 0 to 7 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; slightly hard, friable; many fine roots; medium acid; abrupt, smooth boundary.

A —7 to 14 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, granular structure; slightly hard, friable; common fine roots; slightly acid; clear, smooth boundary.

B1—14 to 19 inches, grayish-brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; weak, medium, subangular blocky structure; slightly hard, friable; common fine roots; neutral; gradual, smooth boundary.

B21t—19 to 36 inches, dark-brown (10YR 4/3) silty clay loam, dark brown (10YR 3/3) moist; moderate, medium, subangular blocky structure; hard, firm; few fine roots; few, fine, black concretions; nearly continuous clay films on faces of peds; neutral; gradual, smooth boundary.

B22t—36 to 48 inches, brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) moist; moderate, medium, blocky structure; hard, firm; few fine roots; few, fine, black concretions; nearly continuous clay films on faces of peds; mildly alkaline; gradual, smooth boundary.

B23t—48 to 60 inches, brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) moist; weak, medium, blocky structure; hard, firm; few, fine, black concretions; nearly continuous clay films on faces of peds; few, fine, soft masses and films of secondary carbonates; few fine concretions of calcium carbonate; calcareous; moderately alkaline; gradual, smooth boundary.

B3—60 to 66 inches, brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) moist; weak, medium, blocky structure; hard, firm; few, fine, black concretions; patchy clay films on faces of peds; few, fine, soft masses and films of secondary carbonates; few fine concretions of calcium carbonate; calcareous; moderately alkaline.

The Ap or A1 horizon is brown, dark brown, grayish brown, or dark grayish brown. It is medium acid or slightly acid. The B1 horizon is brown, dark-brown, grayish-brown, or dark grayish-brown loam, silt loam, or silty clay loam. It is slightly acid or neutral. The B21t and B22t horizons are brown, dark-brown, yellowish-brown, or dark yellowish-brown clay loam or silty clay loam. They are neutral or mildly alkaline. The B23t and B3 horizons are brown, dark brown, yellowish-brown, dark yellowish-brown, or reddish-yellow silty clay loam or clay loam. They are neutral to moderately alkaline. In some areas the B3 horizon is mottled in shades of brown. Bedrock is at a depth of more than 60 inches.

PkA—Pond Creek silt loam, 0 to 1 percent slopes. This soil is nearly level. It has the profile described as representative of the series. Included in mapping are areas of Bethany soils that make up about 10 percent of the mapping unit and spots of Norge and Minco soils.

This soil is used mostly for alfalfa, cotton, grain sorghum, peanuts, small grain, and tame pasture. A small acreage is in native grasses and is used for range and hay.

The main concern of management is maintaining soil structure and fertility. Crop residue is needed. Where large amounts of crop residue are returned to the soil, plant nutrients are needed. Changing the depth of tillage and tilling when the soil is least compacted prevent the formation of a tillage pan. Capability unit I–2; pasture and hay group 8A; Loamy Prairie range site; tree group 7.

PkB—Pond Creek silt loam, 1 to 3 percent slopes. This soil is very gently sloping. The mapping unit is about 8 percent included areas of Minco soils and 10 percent Norge soils.

The soil is used mostly for small grain, cotton, grain sorghum, peanuts, alfalfa, and tame pasture. A small acreage is in native grasses and is used for range and hay.

The main concerns of management are controlling erosion and maintaining soil structure and fertility. Erosion can be controlled by leaving crop residue on the surface. Terracing is needed in some areas where no residue is maintained on the surface. Where large amounts of crop residue are returned to the soil, plant nutrients are needed. Changing the depth of tillage and tilling when the soil is least compacted prevent the formation of a tillage pan. Capability unit IIe–1; pasture and hay group 8A; Loamy Prairie range site; tree group 7.

Port Series

The Port series consists of nearly level soils on flood plains. These soils formed under a cover of grasses in material weathered from loamy sediments.

In a representative profile the surface layer is brown and dark-brown silt loam about 30 inches thick. The subsoil, about 20 inches thick, is reddish-brown silt loam. The underlying material is reddish-brown silt loam and red silty clay loam to a depth of 70 inches.

Port soils are well drained. Permeability is moderate, and the available water capacity is high. The water table is at a depth of more than 6 feet.

Representative profile of Port silt loam, 2,000 feet west and 50 feet south of the northeast corner of sec. 11, T. 14 N., R. 7 W.

A11—0 to 16 inches, brown (7.5YR 5/2) silt loam, dark brown (7.5YR 3/2) moist; moderate, medium, granular structure; slightly hard, friable; many fine roots; neutral; gradual, smooth boundary.

A12—16 to 30 inches, dark-brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; moderate, fine, granular structure; hard, friable; many fine roots; mildly alkaline; gradual, smooth boundary.

B2—30 to 50 inches, reddish-brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) moist; weak, fine, subangular blocky structure; hard, friable; few fine roots; few films of secondary carbonates; calcareous; mildly alkaline; gradual, smooth boundary.

C1—50 to 60 inches, reddish-brown (5YR 4/4) silt loam, dark reddish brown (5YR 3/4) moist; massive; hard, friable; few, fine, soft masses and films of secondary carbonates; calcareous; moderately alkaline; clear, smooth boundary.

C2—60 to 70 inches, red (2.5YR 4/6) silty clay loam, dark red (2.5YR 3/6) moist; massive; hard, firm; calcareous; moderately alkaline.

Depth to soft, powdery secondary carbonates ranges from 24 to 60 inches. The A1 or Ap horizon is brown, dark-brown, reddish-brown, reddish-gray, or dark reddish-gray silt loam or silty clay loam. It is neutral or mildly alkaline. The B2 horizon is brown, dark-brown, reddish-brown, yellowish-red, reddish-gray, or dark reddish-gray silt loam or silty clay loam. It is mildly alkaline or moderately alkaline. The C horizon is reddish-brown, brown, strong-brown, red, or yellowish-red silt loam or silty clay loam. In some areas there is a C horizon that is thinly stratified with coarse-textured or fine-textured sediments. In some areas there are buried horizons of brown, dark-brown, grayish-brown, dark grayish-brown, reddish-brown, or dark reddish-gray silt loam or silty clay loam. Bedrock is at a depth of more than 60 inches.

Po—Port silt loam. This soil is nearly level and is occasionally subject to flooding. It has the profile described as representative of the series. Included in mapping are Yahola soils that make up about 5 percent of the acreage and, making up about 10 percent, areas of soils that are similar to Port soils but have a dark-colored surface layer that is less than 20 inches thick.

This Port soil is used mostly for alfalfa, cotton, grain sorghum, small grain, and tame pasture.

The main concerns of management are controlling flooding and maintaining fertility and soil structure. A moderate to large amount of plant residue should be returned to the soil annually. Crop residue and plant nutrients maintain soil fertility at a high level and maintain soil structure. Changing the depth of tillage and tilling when the soil is least compacted prevent the formation of a tillage pan. Upstream flood control structures and channel improvement reduce the hazard of flooding. Capability unit IIw–1; pasture and hay group 2A; Loamy Bottomland range site; tree group 3.

Pw—Port soils, frequently flooded. These soils are nearly level and are frequently subject to flooding. They have a profile similar to the one described as representative of the series, but the surface layer is silty clay loam or silt loam. Included areas of Yahola soils make up about 10 percent of the mapping unit. It is about 15 percent areas of soils that are similar to Port soils, but the dark-colored surface layer is less than 20 inches thick.

The soils are used mostly for native grasses. They are also suited to tame pasture.

The main concerns of management are controlling flooding and maintaining soil fertility. Management practices suitable for areas used for range and tame pasture are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." Upstream flood control structures and channel improvement reduce the hazard of flooding. Capability unit Vw–2; pasture and hay group 2A; Loamy Bottomland range site; tree group 3.

Quinlan Series

The Quinlan series consists of gently sloping to steep soils on uplands. These soils formed under a cover of grasses in material weathered from sandstone.

In a representative profile the surface layer is reddish-brown loam about 7 inches thick. The subsoil is red loam about 5 inches thick. The underlying material is red sandstone to a depth of 60 inches.

Quinlan soils are well drained. Permeability is moderately rapid, and the available water capacity is low. The water table is at a depth of more than 6 feet.

Representative profile of Quinlan loam in an area of Quinlan-Rock outcrop complex, 12 to 30 percent slopes, 1,000 feet south and 800 feet east of the northwest corner of sec. 5, T. 12 N., R. 10 W.

A1—0 to 7 inches, reddish-brown (2.5YR 4/4) loam, dark reddish brown (2.5YR 3/4) moist; weak, medium, granular structure; slightly hard, friable; many fine roots; calcareous; moderately alkaline; gradual, smooth boundary.

B2—7 to 12 inches, red (2.5YR 4/6) loam, dark red (2.5YR 3/6) moist; weak, medium, granular structure; slightly hard, friable; many fine roots; few fine fragments of sandstone; few films of soft, powdery secondary carbonates; calcareous; moderately alkaline; clear, wavy boundary.

C—12 to 60 inches, red (2.5YR 5/6), weakly consolidated sandstone, red (2.5YR 4/6) moist; moderately alkaline.

Depth to bedrock ranges from 10 to 20 inches. The A1 or Ap horizon is reddish brown or yellowish red. The A1 and B2 horizons are loam, fine sandy loam, or very fine sandy loam. The B2 horizon is reddish brown, red, or yellowish red. The C horizon is red or dark-red sandstone that is rippable.

QdE—Quinlan-Dill complex, 5 to 12 percent slopes. This mapping unit consists of sloping and strongly sloping soils. The Dill soil is in slightly concave areas between areas of the Quinlan soil. The Quinlan soil has a profile similar to the one described as representative of the Quinlan series, but the surface layer is loam, fine sandy loam, or very fine sandy loam. The Quinlan soil is on crests and side slopes.

This mapping unit is about 66 percent Quinlan soils, 17 percent Dill soils, 2 percent Grant soils, 3 percent Albion soils, and 12 percent soils that are similar to Quinlan soils but are less than 10 inches deep over bedrock.

This mapping unit is used for native grasses. It is also suited to tame pasture.

The main concerns of management are controlling soil blowing and erosion and keeping the grasses growing vigorously. Management practices suitable for areas used for range and tame pasture are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." Capability unit VIe–5; tree group 8; Quinlan soil in pasture and hay group 14A and Shallow Prairie range site; Dill soil in pasture and hay group 8A and Sandy Prairie range site.

QrF—Quinlan-Rock outcrop complex, 12 to 30 percent slopes. This mapping unit consists of moderately steep to steep soils and areas of Rock outcrop. The Quinlan soil is on crests and side slopes. Rock outcrop consists of outcroppings of sandstone on crests and escarpments of the side slopes between areas of the Quinlan soil. The Quinlan soil has the profile described as representative of the Quinlan series, but in places the surface layer is loam, fine sandy loam, or very fine sandy loam.

The mapping unit is about 54 percent Quinlan soils, 15 percent Rock outcrop, 6 percent Albion soils, 7 percent Dill soils, 2 percent Minco soils, 1 percent Noble soils, and 15 percent soils that are similar to Quinlan soils but are less than 10 inches deep over bedrock.

The Quinlan soil in this mapping unit is used for native grasses.

The main concern of management is controlling erosion. Management practices suitable for areas used for range are suggested in the section "Range." Capability unit VIIs–1; tree group 9; pasture and hay group not assigned; Quinlan soil in Breaks range site, and Rock outcrop not assigned to a range site.

Reinach Series

The Reinach series consists of nearly level soils on flood plains. These soils formed under a cover of grasses in loamy sediments.

In a representative profile the surface layer is dark-brown very fine sandy loam about 24 inches thick. The subsoil, about 22 inches thick, is reddish-brown very fine sandy loam. The underlying material is reddish-brown very fine sandy loam to a depth of 60 inches.

Reinach soils are well drained. Permeability is moderate, and the available water capacity is high. The water table is at a depth of more than 6 feet.

Representative profile of Reinach very fine sandy loam, about 150 feet north and 500 feet west of the southeast corner of sec. 17, T. 12 N., R. 10 W.

Ap—0 to 8 inches, dark-brown (7.5YR 4/2) very fine sandy loam, dark brown (7.5YR 3/2) moist; weak, fine, granular structure; slightly hard, friable; neutral; plowed boundary.

A11—8 to 16 inches, dark-brown (7.5YR 4/2) very fine sandy loam, dark brown (7.5YR 3/2) moist; moderate, fine, granular structure; slightly hard, friable; mildly alkaline; gradual, smooth boundary.

A12—16 to 24 inches, dark-brown (7.5YR 4/3) very fine sandy loam, dark brown (7.5YR 3/3) moist; moderate, fine, granular structure; slightly hard, friable; calcareous; moderately alkaline; gradual, smooth boundary.

B2—24 to 46 inches, reddish-brown (5YR 4/3) very fine sandy loam, dark reddish brown (5YR 3/3) moist; weak, coarse, prismatic structure; slightly hard, friable; few films of soft, powdery calcium carbonate; calcareous; moderately alkaline; gradual, smooth boundary.

C—46 to 60 inches, reddish-brown (5YR 4/4) very fine sandy loam, dark reddish brown (5YR 3/4) moist; structureless; slightly hard, friable; calcareous; moderately alkaline.

The A1 or Ap horizon is dark brown, brown, or reddish brown. It is neutral to moderately alkaline. The B2 horizon is reddish brown, brown, yellowish red, or red. It is mildly alkaline or moderately alkaline. The C horizon is reddish brown or yellowish red. Bedrock is at a depth of more than 60 inches.

Ra—Reinach very fine sandy loam. This soil is nearly level and is rarely subject to flooding. Included in mapping are spots of Canadian, Port, and Yahola soils. Also included, and making up about 10 percent of the mapping unit, are areas of soils that are similar to Reinach soils, but the dark-colored surface layer is less than 20 inches thick.

The soil is used mostly for alfalfa, cotton, grain sorghum, peanuts, small grain, and tame pasture.

The main concern of management is maintaining soil structure and fertility. Where adequate amounts of crop residue and plant food are returned to the soil annually, soil structure and fertility are improved. Changing the depth of tillage and tilling when the soil is least compacted prevent the formation of a tillage pan. Capability unit I–1; pasture and hay group 2A; Loamy Bottomland range site; tree group 3.

Renfrow Series

The Renfrow series consists of nearly level to gently sloping soils on uplands. These soils formed under a cover of grasses in material weathered from clay or shale.

In a representative profile the surface layer is dark-brown silt loam about 11 inches thick. The upper 7 inches of the subsoil is reddish-brown silty clay loam; the next 30 inches is reddish-brown silty clay; and the lower 17 inches is red silty clay.

Renfrow soils are well drained. Permeability is very slow, and the available water capacity is high. The water table is at a depth of more than 6 feet.

Representative profile of Renfrow silt loam, 1 to 3 percent slopes, 2,000 feet north and 200 feet east of the southwest corner of sec. 4, T. 13 N., R. 5 W.

A1—0 to 11 inches, dark-brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; moderate, medium, granular structure; slightly hard, friable; many fine roots; slightly acid; gradual, smooth boundary.

B1—11 to 18 inches, reddish-brown (5YR 4/3) silty clay loam, dark reddish brown (5YR 3/3) moist; moderate, fine and medium, subangular blocky structure; hard, firm; many fine roots; neutral; gradual, smooth boundary.

B21t—18 to 32 inches, reddish-brown (5YR 4/4) silty clay, dark reddish brown (5YR 3/4) moist; strong, medium, blocky structure; very hard, very firm; few fine roots; nearly continuous clay films on faces of peds; neutral; gradual, smooth boundary.

B22t—32 to 48 inches, reddish-brown (2.5YR 4/4) silty clay, dark reddish brown (2.5YR 3/4) moist; moderate, coarse, blocky structure; very hard, very firm; few fine roots; nearly continuous clay films on faces of peds; moderately alkaline; gradual, smooth boundary.

B3—48 to 65 inches, red (2.5YR 4/6) silty clay, dark red (2.5YR 3/6) moist; weak, fine, blocky structure; very hard, very firm; few fine roots; patchy clay films on faces of peds; few films of secondary carbonates; calcareous; moderately alkaline.

The A1 or Ap horizon is brown, dark-brown, or reddish-brown silt loam or clay loam. The B1 horizon is brown, dark-brown, or reddish-brown silty clay loam or clay loam. It is slightly acid or neutral. The B2t horizon is reddish-brown, red,

or yellowish-red clay or silty clay. The B22t horizon is mildly alkaline or moderately alkaline. The B3 horizon is red, weak-red, reddish-brown, or yellowish-red silty clay or clay. In some areas there is a C horizon of reddish-colored shale or clay. Bedrock is at a depth of more than 60 inches.

RbA—Renfrow silt loam, 0 to 1 percent slopes. This soil is nearly level. Included areas of Kirkland soils make about 8 percent of the mapping unit.

The soil is used mostly for cotton, grain sorghum, small grain, and tame pasture. A small acreage is in native grasses and is used for range and hay.

The main concerns of management are controlling erosion and maintaining soil structure and fertility. Crop residue is needed. Where large amounts of crop residue are returned to the soil, plant nutrients also are needed. Changing the depth of tillage and tilling when the soil is least compacted prevent the formation of a tillage pan. Capability unit IIs–1; pasture and hay group 8C; Claypan Prairie range site; tree group 5.

RbB—Renfrow silt loam, 1 to 3 percent slopes. This soil is very gently sloping. It has the profile described as representative of the series. Included areas of Kirkland soils make up about 7 percent of the mapped acreage, Kingfisher soils make up 5 percent, Norge soils 3 percent, and Vernon soils 5 percent.

This soil is used mostly for cotton, grain sorghum, small grain, and tame pasture. A small acreage is in native grass and is used for range and hay.

The main concern of management is controlling erosion and maintaining soil fertility and structure. Most of the adapted crops can be grown year after year if the soil is well managed and crop residue is returned to it. Contour farming and terracing are needed where row crops are grown. Changing the depth of tillage and tilling when the soil is least compacted prevent the formation of a tillage pan. Capability unit IIIe–1; pasture and hay group 8C; Claypan Prairie range site; tree group 5.

RcC2—Renfrow clay loam, 2 to 5 percent slopes, eroded. This soil is very gently sloping to gently sloping. It has a profile similar to the one described as representative of the series, but the plow layer of clay loam is a mixture of the original surface layer and the subsoil on about 25 percent of the total acreage. Also, small rills are common.

Included in mapping, and making up about 20 percent of the mapping unit, are areas of soils that are similar to Renfrow soils but are less than 60 inches deep over bedrock. Also included are areas of Vernon soils that make up about 10 percent of the unit.

The soil is used mostly for small grain, tame pasture, and native grasses.

The main concerns of management are maintaining fertility and soil structure, preventing surface crusting, and controlling erosion. Terracing and contour farming are needed to reduce runoff and erosion. Plant nutrients are needed where large amounts of crop residue are returned to the soil or left on the surface. Leaving crop residue on the surface at crop seeding time helps control erosion. Management practices suitable for areas used for range and tame pasture are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." Capability unit IVe–1; pasture and hay group 8C; Claypan Prairie range site; tree group 5.

Rock Outcrop

Rock outcrop consists of sloping to steep outcroppings of sandstone and shale on uplands. It is mapped only with Quinland and Vernon soils.

Shellabarger Series

The Shellabarger series consists of very gently sloping to strongly sloping soils on uplands. These soils formed under a cover of grasses in material weathered from loamy sediments.

In a representative profile the surface layer is brown and dark grayish-brown fine sandy loam about 12 inches thick. The upper 7 inches of the subsoil is brown sandy clay loam; the next 17 inches is reddish-brown sandy clay loam; and the lower 24 inches is yellowish-red sandy loam.

Shellabarger soils are well drained. Permeability is moderate, and the available water capacity is medium. The water table is at a depth of more than 6 feet.

Representative profile of Shellabarger fine sandy loam, 1 to 3 percent slopes, about 150 feet south and 2,500 feet west of the northeast corner of sec. 31, T. 14 N., R. 8 W.

Ap—0 to 7 inches, brown (10YR 5/3) fine sandy loam, dark brown (10YR 3/3) moist; weak, fine, granular structure; slightly hard, very friable; slightly acid; plowed boundary.

A11—7 to 12 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak, fine, granular structure; slightly hard, very friable; slightly acid; gradual, smooth boundary.

B1—12 to 19 inches, brown (10YR 4/3) sandy clay loam, dark brown (10YR 3/3) moist; weak, medium, subangular blocky structure; hard, friable; patchy clay films on faces of peds; slightly acid; gradual, smooth boundary.

B2t—19 to 36 inches, reddish-brown (5YR 4/4) sandy clay loam, dark reddish brown (5YR 3/4) moist; weak, medium, prismatic structure parting to weak, coarse, subangular blocky; hard, firm; thin clay films on faces of peds; neutral; gradual, smooth boundary.

B3—36 to 60 inches, yellowish-red (5YR 5/6) sandy loam, yellowish red (5YR 4/6) moist; few, coarse, faint, reddish-yellow mottles; weak, medium, prismatic structure; slightly hard, friable; mildy alkaline.

The A1 or Ap horizon is brown, dark grayish brown, very dark grayish brown, grayish brown, or dark brown. The B1 horizon is brown, dark grayish-brown, grayish-brown, dark-brown, or brown sandy clay loam or sandy loam. The B2t horizon is reddish-brown, yellowish-red, or reddish-yellow sandy clay loam or sandy loam. It is slightly acid to mildly alkaline. The B3 horizon is yellowish red, reddish brown, or reddish yellow. It is neutral to moderately alkaline. Bedrock is at a depth of more than 60 inches.

ShB—Shellabarger fine sandy loam, 1 to 3 percent slopes. This soil is very gently sloping. It has the profile described as representative of the series. Included in mapping are spots of Konawa and Norge soils.

This soil is used for alfalfa, cotton, grain sorghum, peanuts, small grain, and tame pasture. Some areas are in native grasses and are used for range and hay.

The main concerns of management are controlling soil blowing and erosion and maintaining soil structure and fertility. Where adequate amounts of crop residue and plant nutrients are returned to the soil, erosion is controlled and soil structure and fertility are improved. Seeding crops with a deep-furrow drill at right angles to the prevailing wind also helps control soil blowing. Plant nutrients are generally needed. Capability unit IIe–2; pasture and hay group 8A; Sandy Prairie range site; tree group 7.

ShC—Shellabarger fine sandy loam, 3 to 5 percent slopes. This soil is gently sloping. Included with it in mapping are spots of Albion, Konawa, Grant, Kingfisher, and Norge soils.

The soil is used for small grain, cotton, grain sorghum, peanuts, tame pasture, and native grasses.

The main concerns of management are controlling soil blowing and erosion and maintaining soil structure and fertility. Leaving crop residue on the surface at crop seeding time reduces the hazard of soil blowing and permits wider spacing between terraces used to control erosion. Plant nutrients are needed where large amounts of crop residue are returned to the soil or are left on the surface. Capability unit IIIe–3; pasture and hay group 8A; Sandy Prairie range site; tree group 7.

ShD—Shellabarger fine sandy loam, 5 to 8 percent slopes. This soil is sloping. Included with it in mapping are areas of Konawa and Albion soils that make up about 5 percent of the acreage and areas of Norge soils that make up 3 percent.

This soil is used mostly for native grasses and wheat. It is also suited to small grain and tame pasture.

The main concern in grass management is to keep the grasses growing vigorously. Management practices suitable for areas used for range and tame pasture are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." In cultivated areas the main concerns of management are controlling soil blowing and erosion and maintaining soil structure and fertility. Returning crop residue to the soil and adding plant nutrients are good management practices. Terraces that have protected outlets, contour farming, and minimum tillage are needed. Capability unit IVe–5; pasture and hay group 8A; Sandy Prairie range site; tree group 7.

ShD2—Shellabarger fine sandy loam, 3 to 8 percent slopes, eroded. This eroded soil is gently sloping and sloping. It has a profile similar to the one described as representative of the series, but the surface layer is thinner and is mixed with the subsoil in about 40 percent of the acreage. About 5 percent of the mapping unit is included areas of Albion soils; 5 percent is Konawa soils; 3 percent is Grant soils; 2 percent is Kingfisher soils; and 2 percent is Norge soils and spots of soils that are similar to Shellabarger soils, but the subsoil is exposed at the surface.

This soil is used mostly for native grasses. It is also suited to tame pasture and small grain.

The main concerns of grass management are described in the sections "Range" and "Cultivated Crops and Tame Pasture." In cultivated areas the main concerns of management are controlling soil blowing and erosion and maintaining soil structure and fertility. Returning crop residue to the soil and adding plant nutrients are good management practices. Terraces that have protected outlets, contour farming, and minimum tillage are needed. A moderate to large amount of residue should be returned to the soil annually. Capability unit IVe–6; pasture and hay group 8A; Sandy Prairie range site; tree group 7.

SnE—Shellabarger-Albion complex, 5 to 12 percent slopes. This mapping unit consists of sloping and strongly sloping soils. The Shellabarger soil is on side slopes, and the Albion soil is on crests and upper slopes. The Shellabarger soil has a profile similar to the one described as representative of the Shellabarger series, but the surface layer is slightly thinner. The Albion soil has the profile described as representative of the Albion series.

This mapping unit is about 60 percent Shellabarger soils, 30 percent Albion soils, 5 percent Dill soils, and 5 percent Quinlan soils.

The mapping unit is used mostly for native grasses. It is also suited to tame pasture grasses.

The main concerns of management are controlling soil blowing and erosion and keeping the grasses growing vigorously. Management practices suitable for areas used for range and tame pasture are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." Capability unit VIe–6; pasture and hay group 8A; Sandy Prairie range site; tree group 7.

Tivoli Series

The Tivoli series consists of strongly sloping and moderately steep soils on uplands. These soils formed under a cover of grasses and sand sagebrush in sandy sediments.

In a representative profile the surface layer is brown fine sand about 10 inches thick. The underlying material is very pale brown fine sand to a depth of 60 inches.

Tivoli soils are excessively drained. Permeability is rapid, and the available water capacity is low. The water table is at a depth of more than 6 feet.

Representative profile of Tivoli fine sand, about 1,300 feet east and 1,300 feet south of the northwest corner of sec. 17, T. 14 N., R. 10 W.

A1—0 to 10 inches, brown (10YR 5/3) fine sand, dark brown (10YR 4/3) moist; massive; loose, very friable; neutral; gradual, smooth boundary.

C—10 to 60 inches, very pale brown (10YR 7/4) fine sand, light yellowish brown (10YR 6/4) moist; massive; loose, very friable; mildly alkaline.

The A1 horizon is brown, grayish brown, yellowish brown, pale brown, or light yellowish brown. It is slightly acid to mildly alkaline. The C horizon is very pale brown, pale brown, light yellowish brown, or brownish yellow. It is mildly alkaline or moderately alkaline. Bedrock is at a depth of more than 60 inches.

Tv—Tivoli fine sand. This soil is strongly sloping to moderately steep. Included with it in mapping are areas of Gracemore soils that make up about 5 percent of the acreage and areas of Yahola and Canadian soils that make up 2 percent each.

This soil is used mainly for native grasses.

The main concerns of grass management are controlling soil blowing and keeping the grasses growing vigorously. Suitable management practices are suggested in the section "Range." Capability unit VIIe–1; Dune range site; tree group 6; pasture and hay group not assigned.

Vernon Series

The Vernon series consists of gently sloping to moderately steep soils on uplands. These soils formed under a cover of grasses in material weathered from shale and clayey sediments.

In a representative profile the surface layer is reddish-brown clay loam about 6 inches thick. The subsoil, about 18 inches thick, is reddish-brown clay. The underlying material is red clay and shale to a depth of 60 inches.

Vernon soils are well drained. Permeability is very slow, and the available water capacity is low. The water table is at a depth of more than 6 feet.

Representative profile of Vernon clay loam, 3 to 5 percent slopes, about 300 feet north and 50 feet east of the southwest corner of sec. 8, T. 13 N., R. 5 W.

A1—0 to 6 inches, reddish-brown (5YR 4/4) clay loam, dark reddish brown (5YR 3/4) moist; moderate, medium, granular structure; very hard, friable; calcareous; moderately alkaline; clear, smooth boundary.
B2—6 to 24 inches, reddish-brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) moist; moderate, medium, blocky structure; very hard, very firm; calcareous; moderately alkaline; diffuse, smooth boundary.
C1—24 to 32 inches, red (2.5YR 4/6) clay, dark red (2.5YR 3/6) moist; massive; extremely firm; calcareous; moderately alkaline; clear, smooth boundary.
C2—32 to 60 inches, red (2.5YR 4/6) bedded shale, dark red (2.5YR 3/6) moist; calcareous; moderately alkaline.

The A1 or Ap horizon is reddish-brown or red clay loam or clay. The B2 horizon is reddish brown or red. The C horizon is red or reddish-brown clay or shale. Shale or clay bedrock is at a depth of 20 to 36 inches.

VeC—Vernon clay loam, 3 to 5 percent slopes. This soil is gently sloping. It has the profile described as representative of the series. Included in mapping are areas of Kingfisher soils that make up about 5 percent of the acreage. Norge soils make up 5 percent, Renfrow soils make up 15 percent, and soils that are similar to Vernon soils but less than 20 inches deep make up 10 percent.

The soil is used mostly for grain sorghum, small grain, tame pasture, and native grasses.

The main concerns of management are maintaining fertility and soil structure, preventing surface crusting, and controlling erosion. Terracing and contour farming are needed to reduce runoff and erosion. Plant nutrients are needed where large amounts of crop residue are returned to the soil or left on the surface. Leaving crop residue on the surface at crop seeding time helps control erosion. Management practices suitable for areas used for range and tame pasture are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." Capability unit IVe–1; pasture and hay group 7A; Red Clay Prairie range site; tree group 8.

VrE—Vernon-Rock outcrop complex, 5 to 15 percent slopes. This mapping unit consists of sloping to moderately steep soils and areas of Rock outcrop. The Vernon soil is on crests and side slopes between areas of Rock outcrop. The Vernon soil has a profile similar to the one described as representative of the Vernon series, but the surface layer is clay loam or clay. Rock outcrop is shale bedrock exposed at the surface. The mapping unit is about 70 percent Vernon soils, 20 percent Rock outcrop, and 5 percent each of Renfrow soils and clayey flood plain soils.

The Vernon soil in this mapping unit is used for native grasses.

The main concern of management is controlling erosion. Suitable management practices are suggested in the section "Range." Capability unit VIIs–2; pasture and hay group not assigned; Vernon soil in Red Clay Prairie range site and tree group 9; Rock outcrop not assigned to a range site or tree group.

VsC2—Vernon soils, 3 to 5 percent slopes, eroded. This mapping unit consists of gently sloping, eroded soils. They have profiles similar to the one described as representative of the series, but the surface layer is thinner and is clay loam or clay. Small rills and shallow gullies are common.

Included with these soils in mapping are areas of Kingfisher soils that make up about 5 percent of the acreage. Renfrow soils make up 15 percent, and soils that are similar to Vernon soils but less than 20 inches deep make up 15 percent.

The soils are used for native grasses and tame pasture.

The main concerns of management are controlling erosion and keeping the grasses growing vigorously. Suitable management practices are suggested in the sections "Range" and "Cultivated Crops and Tame Pasture." Capability unit VIe–7; pasture and hay group 7A; Red Clay Prairie range site; tree group 8.

Watonga Series

The Watonga series consists of nearly level soils on flood plains. These soils formed under a cover of grasses in material weathered from clayey sediments.

In a representative profile the surface layer is dark-gray and very dark gray silty clay about 22 inches thick. The next layer, to a depth of 50 inches, is brown silty clay. The underlying material is light-brown silty clay to a depth of 72 inches.

Watonga soils are moderately well drained. Permeability is very slow, and the available water capacity is high. The water table is at a depth of more than 6 feet.

Representative profile of Watonga silty clay, about 4,500 feet east and 50 feet north of the southwest corner of sec. 23, T. 12 N., R. 5 W.

Ap—0 to 8 inches, dark-gray (10YR 4/1) silty clay, black (10YR 2/1) moist; moderate, fine, granular structure; very hard, very firm; few roots; calcareous; mildly alkaline; abrupt, smooth boundary.
A12—8 to 22 inches, very dark gray (10YR 3/1) silty clay, black (10YR 2/1) moist; strong, fine, granular and subangular blocky structure; very hard, very firm; few roots; calcareous; moderately alkaline; gradual, wavy boundary.
AC—22 to 50 inches, brown (10YR 5/3) silty clay, dark brown (10YR 4/3) moist; moderate, coarse, blocky structure; shiny pressure faces on faces of peds; few intersecting slickensides; few parallelepipeds; extremely hard, extremely firm; dark-colored soil material with moist color of black (10YR 2/1) in some cracks; common fine and medium concretions of calcium carbonate; calcareous; moderately alkaline; gradual, wavy boundary.
C—50 to 72 inches, light-brown (7.5YR 6/4) silty clay, dark brown (7.5YR 4/4) moist; massive; extremely hard, extremely firm; few reddish-brown (5YR 5/4) bodies of silty clay; common medium and coarse concretions of calcium carbonate; calcareous; moderately alkaline.

The Ap or A1 horizon is dark gray or very dark gray. It is mildly alkaline or moderately alkaline. The AC horizon is brown or dark grayish-brown silty clay or silty clay loam. It is mildly alkaline or moderately alkaline. The C horizon, where present, is dark yellowish-brown, dark grayish-brown, brown, or light-brown silty clay or silty clay loam. It is mildly alkaline or moderately alkaline. Bedrock is at a depth of more than 60 inches.

Wa—Watonga silty clay. This soil is nearly level and is rarely subject to flooding. Included with it in mapping are areas of Brewer soils that make up about 3 percent of the acreage, areas of Dale soils that make up 10 percent, and spots of Reinach soils.

The soil is used for alfalfa, cotton, grain sorghum, small grain, and tame pasture.

The main concerns of management are controlling flooding and maintaining soil structure. Returning adequate amounts of crop residue to the soil annually helps maintain soil structure and fertility. Plant nutrients are needed where large amounts of crop residue are returned to the

soil. A drainage system is beneficial to most crops. Upstream flood control structures reduce the hazard of flooding. Capability unit IIIw–1; pasture and hay group 1A; Heavy Bottomland range site; tree group 4.

Yahola Series

The Yahola series consists of nearly level soils on flood plains. These soils formed under a cover of grasses in loamy and sandy sediments.

In a representative profile the surface layer is reddish-brown and brown fine sandy loam about 18 inches thick. The upper 22 inches of the underlying material is brown fine sandy loam; the lower part is pink loamy fine sand to a depth of 60 inches.

Yahola soils are well drained. Permeability is moderately rapid, and the available water capacity is medium. The water table is at a depth of more than 6 feet.

Representative profile of Yahola fine sandy loam, about 200 feet west and 200 feet north of the southeast corner of sec. 5, T. 12 N., R. 10 W.

A11—0 to 12 inches, reddish-brown (5YR 4/4) fine sandy loam, dark reddish brown (5YR 3/4) moist; weak, fine, granular structure; soft, very friable; calcareous; moderately alkaline; clear, smooth boundary.

A12—12 to 18 inches, brown (7.5YR 4/4) fine sandy loam, dark brown (7.5YR 3/4) moist; weak, fine, granular structure; soft, very friable; calcareous; moderately alkaline; gradual, smooth boundary.

C1—18 to 40 inches, brown (7.5YR 5/4) fine sandy loam, dark brown (7.5YR 4/4) moist; massive; slightly hard, friable; weak bedding planes; calcareous; moderately alkaline; gradual, smooth boundary.

C2—40 to 60 inches, pink (7.5YR 7/4) loamy fine sand, light brown (7.5YR 6/4) moist; massive; loose; thinly stratified with brown (7.5YR 5/4) fine sandy loam; calcareous; moderately alkaline.

The A1 or Ap horizon is reddish brown, brown, or yellowish red. The C horizon is brown, reddish-brown, yellowish-red, reddish-yellow, pink, strong-brown, or light reddish-brown fine sandy loam or loamy fine sand. Bedrock is at a depth of more than 60 inches.

Ya—Yahola fine sandy loam. This soil is nearly level and is occasionally subject to flooding. Included in mapping are areas of Canadian soils that make up about 10 percent of the acreage, Gracemore soils that make up 5 percent, and Tivoli soils that make up 5 percent.

The soil is used mostly for alfalfa, cotton, grain sorghum, small grain, and tame pasture.

The main concerns of management are controlling flooding and maintaining fertility and soil structure. Returning a moderate to large amount of plant residue to the soil annually and adding plant nutrients maintain soil fertility at a high level and maintain soil structure. Changing the depth of tillage and tilling when the soil is least compacted prevent the formation of a tillage pan. Upstream flood control structures and channel improvement reduce the hazard of flooding. Capability unit IIw–1; pasture and hay group 2A; Loamy Bottomland range site; tree group 2.

Use and Management of the Soils

This section explains the system of capability classification used by the Soil Conservation Service and shows estimated yields of principal crops grown in the county. The capability classification of each soil mapped in the county can be found by referring to the "Guide to Mapping Units." Information about management needs of a particular soil for cultivated crops is in the section "Descriptions of the Soils," and information about management needs for native grasses and tame pasture grasses is in the sections "Range" and "Cultivated Crops and Tame Pasture."

This section also contains information about management of the soils for trees, wildlife habitat, and engineering.

Cultivated Crops and Tame Pasture [2]

Soils used for cultivated crops need management that conserves moisture, controls erosion, maintains soil fertility and structure, supplies organic matter, and preserves good tilth. Some of the management practices commonly needed in the county are minimum tillage and use of crop residue. For suggested combinations of practices for specific soils, see "Descriptions of the Soils."

The information in this section can be used with that in the descriptions of the mapping units to help the land user select appropriate practices for specific soils. Most good management practices accomplish more than one purpose and can be used on nearly all of the cropland in the county.

Minimum tillage.—Where soils are cropped, they must be tilled to prepare a seedbed, control weeds, and provide a suitable place for the growth of plant roots. Excessive tillage breaks down soil structure and speeds up the decomposition of organic material. The soils then tend to puddle and crust on the surface and to take in less water and air, resulting in less moisture being stored for plant growth.

Minimum tillage is accomplished by reducing the number of operations considered essential in preparing the seedbed, planting, and cultivating. Using approved herbicides instead of cultivating for weed control is encouraged. Including perennial grasses or legumes in the cropping system is an excellent way to improve the physical condition of the soil.

Crop residue management.—Crop residue can be used to maintain soil structure, help maintain soil fertility, and help control erosion. Where soil blowing is a hazard, large amounts of crop residue should be left on the surface or worked partly into the surface layer. Crop residue supplies organic matter, or humus, which improves soil structure and tilth, reduces the hazard of erosion, and helps prevent crusting. Soil-maintaining crops, such as wheat, produce large amounts of residue. This residue needs additional plant nutrients to maintain soil fertility.

The increase in crop yields in recent years indicates that effective measures for controlling erosion have been applied. Suitable practices for helping to control erosion are growing a winter cover crop, using a suitable cropping system, returning crop residue to the soil, stubble mulching, farming on the contour, installing grassed waterways, and applying plant nutrients. Practices to help control insects and plant diseases also are needed. On soils that are subject to erosion, terraces should be planned to help keep soil loss within acceptable limits.

[2] By M. D. Gamble, conservation agronomist, Soil Conservation Service.

Soils used for tame pasture grasses need management that conserves moisture, controls erosion, maintains soil fertility and structure, and produces grasses economically. Tame pasture grasses are an important source of forage for the livestock industry. Where tame pasture grasses are properly managed, erosion is not a hazard. For example, Grandfield soils, 3 to 8 percent slopes, severely eroded, are well suited to tame and native grasses.

Some of the management practices commonly needed are selecting the species of grass best suited to a specific soil, using improved varieties, controlling grazing, applying needed plant nutrients, controlling weeds, providing adequate water, and stocking properly.

Bermudagrass, fescue, southland brome, and weeping lovegrass are suited to soils in the county. Improved bermudagrass is more widely grown than the other grasses. It is well suited to Binger, Noble, Dill, Grandfield, Konawa, and Minco soils. Fescue and southland brome provide green forage late in fall and early in spring. Fescue is best suited to wet soils, such as Watonga silty clay. Proper management of grasses is needed for optimum plant growth.

Pasture and hay groups

Different kinds of soil vary in their capacity to produce tame pasture grasses for grazing. Soils that produce about the same kind and amount of forage make up a pasture and hay group.

In the following pages the characteristics of the soils in pasture and hay groups of Canadian County, Oklahoma, are briefly described.

Group 1A.—Deep, clayey soils that have a clayey or loamy subsoil. These soils are on flood plains. They are moderately well drained and are rarely subject to flooding.

Group 2A.—Deep, loamy soils that have a loamy or clayey subsoil. These soils are on flood plains. They are well drained, moderately well drained, or somewhat poorly drained and are rarely, occasionally, or frequently subject to flooding.

Group 2C.—Deep, loamy soils that have a loamy subsoil and are high in content of exchangeable sodium. These soils are on flood plains. They are somewhat poorly drained and are rarely subject to flooding.

Group 3B.—Deep, sandy soils that have a sandy subsoil. These soils are on flood plains. They are somewhat poorly drained, have a high water table, and are occasionally or frequently subject to flooding. Small amounts of loamy soils occur in some areas.

Group 7A.—Moderately deep, clayey soils that have a clayey subsoil. These soils are on uplands. They are well drained. Small amounts of loamy soils occur in some areas.

Group 8A.—Deep and moderately deep, loamy soils that have a loamy and clayey subsoil. These soils are on uplands. They are well drained.

Group 8C.—Deep, loamy soils that have a clayey subsoil. These soils are on uplands. They are well drained.

Group 8D.—Deep, loamy soils that have a loamy and clayey subsoil that is high in content of exchangeable sodium. These soils are on uplands. They are moderately well drained.

Group 8F.—Deep, moderately deep, and shallow; severely eroded; loamy and sandy soils that have a loamy subsoil. These soils are on uplands. They are well drained.

Group 9A.—Deep, sandy soils that have a loamy subsoil. These soils are on uplands. They are well drained.

Group 14A.—Shallow, loamy soils that have a loamy subsoil. These soils are on uplands. They are well drained or somewhat excessively drained.

Capability grouping

Some readers, particularly those who farm on a large scale, may find it practical to use and manage alike some of the different kinds of soil on their farms. These readers can make good use of the capability classification system, a grouping that shows, in a general way, the suitability of soils for most kinds of farming.

The grouping is based on limitations of soils when used for field crops, the risk of damage when they are farmed, and the way the soils respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops that require special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations for range, for forest trees, or for engineering.

In the capability system, all kinds of soil are grouped at three levels: the class, the subclass, and the unit. The unit designation for each soil is shown in the "Guide to Mapping Units."

Capability Classes, the broadest groups, are designated by Roman numerals I to VIII. In class I are the soils that have the fewest limitations, the widest range of use, and the least risk of damage when they are used. The soils in other classes have progressively greater natural limitations. In class VIII are landforms so rough and soils so shallow or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products.

Capability Subclasses indicate major kinds of limitations within the classes. The subclasses are indicated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral; for example, *IIe*. The letter *e* indicates that the main limitation is the risk of erosion unless good management practices are used; *w* indicates that water in or on the soil interferes with plant growth or cultivation; *s* indicates that the soil is limited mainly because it is droughty, shallow, saline, or stony; and *c*, used only in some parts of the United States, indicates that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few or no limitations. Class V can obtain, at the most, only subclasses *w*, *s*, and *c*, because the soils are subject to little or no erosion, although they have other limitations that confine their use largely to pasture, range, or wildlife habitat.

Capability Units are groups of soils that are so much alike that they are suited to the same crops and pasture plants. They require about the same management and generally have similar productivity and response to management. Capability units are generally designated by adding an Arabic numeral to the subclass symbol; for example, IIe–1 or IIIs–1. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or

kind of limitation; and the Arabic numeral specifically identifies the capability unit within each subclass.

The eight classes in the capability system and the subclasses and units in Canadian County are described in the list that follows.

Class I soils have few limitations that restrict their use.

Unit I–1.—Deep, nearly level, moderately well drained and well drained fine sandy loams, very fine sandy loams, silt loams, and silty clay loams that have a loamy or clayey subsoil; on flood plains.

Unit I–2.—Deep, nearly level, well-drained silt loams that have a loamy or clayey subsoil; on uplands.

Class II soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.

Subclass IIe.—Soils subject to moderate erosion unless protected.

Unit IIe–1.—Deep and moderately deep, very gently sloping, well-drained silt loams that have a loamy subsoil; on uplands.

Unit IIe–2.—Deep, very gently sloping, well-drained fine sandy loams that have a loamy subsoil; on uplands.

Subclass IIw.—Soils moderately limited by excess water or seasonal flooding.

Unit IIw–1.—Deep, nearly level, well-drained silt loams and fine sandy loams that have a loamy subsoil; on flood plains.

Subclass IIs.—Soils moderately limited by very slow permeability.

Unit IIs–1.—Deep, nearly level, well-drained silt loams that have a clayey subsoil; on uplands.

Class III soils have severe limitations that reduce the the choice of plants, require special conservation practices, or both.

Subclass IIIe.—Soils subject to severe erosion unless protected.

Unit IIIe–1.—Deep, very gently sloping, well-drained silt loams that have a clayey subsoil; on uplands.

Unit IIIe–2.—Deep and moderately deep, gently sloping, well-drained silt loams that have a loamy subsoil; on uplands.

Unit IIIe–3.—Deep and moderately deep, very gently sloping and gently sloping, well-drained fine sandy loams that have a loamy subsoil; on uplands.

Unit IIIe–4.—Deep, nearly level, somewhat poorly drained loamy fine sands that have a sandy subsoil; on flood plains.

Subclass IIIw.—Soils severely limited by excess water.

Unit IIIw–1.—Deep, nearly level, moderately well drained clays that have a loamy or clayey subsoil; on flood plains.

Subclass IIIs.—Soils severely limited by soil features.

Unit IIIs–1.—Deep, very gently sloping, well drained and moderately well drained silt loams that have a loamy and clayey subsoil affected by sodium; on uplands.

Unit IIIs–2.—Deep, nearly level, moderately well drained and somewhat poorly drained loams, silt loams, and silty clay loams that have a clayey or loamy subsoil affected by sodium; on flood plains.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Subclass IVe.—Soils subject to very severe erosion if they are cultivated and not protected.

Unit IVe–1.—Deep and moderately deep, very gently sloping and gently sloping, well-drained clay loams that have a clayey subsoil; on uplands.

Unit IVe–2.—Deep, gently sloping and sloping, well-drained loamy fine sands that have a loamy subsoil; on uplands.

Unit IVe–3.—Deep, moderately deep, and shallow, gently sloping and sloping, well-drained fine sandy loams, very fine sandy loams, loams, and silt loams that have a loamy subsoil; on uplands.

Unit IVe–4.—Deep, moderately deep, and shallow, gently sloping and sloping, well-drained fine sandy loams, very fine sandy loams, loams, and silt loams that are eroded and have a loamy subsoil; on uplands.

Unit IVe–5.—Deep, moderately deep, and shallow, sloping, well-drained fine sandy loams, very fine sandy loams, and loams that have a loamy subsoil; on uplands.

Unit IVe–6.—Deep, very gently sloping to sloping, well-drained fine sandy loams that have a loamy subsoil; on uplands.

Subclass IVs.—Soils very severely limited by high sodium content or other soil features.

Unit IVs–1.—Deep, nearly level and very gently sloping, well drained and moderately well drained silt loams that have a loamy or clayey subsoil affected by sodium; on uplands.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use largely to pasture, range, woodland, and wildlife habitat.

Subclass Vw.—Soils subject to flooding.

Unit Vw–1.—Deep, nearly level, somewhat poorly drained fine sands to clay loams that have a sandy subsoil and a high water table; on flood plains.

Unit Vw–2.—Deep, nearly level, well-drained silt loams or silty clay loams that have a loamy subsoil; on flood plains.

Class VI soils have severe limitations that make them generally unsuitable for cultivation and restrict their use largely to pasture, range, woodland, and wildlife habitat.

Subclass VIe.—Soils limited chiefly by risk of erosion unless protective cover is maintained.

Unit VIe–1.—Deep, nearly level to strongly sloping, well-drained silt loams and silty clay loams that have a loamy subsoil; on uplands and flood plains.

Unit VIe–2.—Deep, moderately deep, and shallow, gently sloping and sloping, well-drained loamy fine sands, fine sandy loams, loams,

and silt loams that are severely eroded and have a loamy subsoil; on uplands.

Unit VIe–3.—Deep and shallow, very gently sloping to sloping, well-drained and somewhat excessively drained fine sandy loams that have a loamy subsoil; on uplands.

Unit VIe–4.—Deep, strongly sloping and steep, well-drained very fine sandy loams that have a loamy subsoil; on uplands.

Unit VIe–5.—Moderately deep and shallow, sloping and strongly sloping, well-drained fine sandy loams, very fine sandy loams, and loams that have a loamy subsoil; on uplands.

Unit VIe–6.—Deep, sloping and strongly sloping, well-drained fine sandy loams that have a loamy subsoil; on uplands.

Unit VIe–7.—Moderately deep, gently sloping, well-drained clay loams and clays that have a clayey subsoil; on uplands.

Class VII soils have very severe limitations that make them unsuitable for cultivation and restrict their use largely to pasture, range, woodland, and wildlife habitat.

Subclass VIIe.—Soils very severely limited, chiefly by risk of erosion, unless protective cover is maintained.

Unit VIIe–1.—Deep, strongly sloping to steep, excessively drained fine sands that have a sandy subsoil; on uplands.

Unit VIIe–2.—Shallow or deep, strongly sloping to steep, somewhat excessively drained and well-drained fine sandy loams that have a loamy subsoil; on uplands.

Subclass VIIs.—Soils very severely limited by slope, shallowness, stones, or other soil features.

Unit VIIs–1.—Shallow, moderately steep and steep, well-drained loams, fine sandy loams, and very fine sandy loams that have a loamy subsoil; on uplands.

Unit VIIs–2.—Moderately deep, sloping to moderately steep, well-drained clay loams and clays that have a clayey subsoil; on uplands.

Class VIII land types have limitations that preclude their use for commercial crop production and restrict their use to recreation, wildlife habitat, water supply, and esthetic purposes. (None in Canadian County.)

Estimated yields

Table 2 lists estimated yields of the principal crops grown in the county. The figures are based on estimates made by farmers, soil scientists, and others who have knowledge of yields in the county and on information taken from research data. The estimated yields are average yields per acre that can be expected under high-level management.

Crops other than those shown in table 2 are grown in the county, but their acreage is small or reliable data on yields are not available. Absence of a yield indicates the crop is not suited to the soil or is not commonly grown on it.

Under high-level management—

1. Rainfall is effectively used and conserved.
2. Crop residue is managed to maintain soil structure and soil tilth.
3. Minimum but timely tillage is used.
4. Insects, plant diseases, and weeds are consistently controlled.
5. Plant nutrients are applied according to soil test and crop needs.
6. Adapted crop varieties are planted at recommended seeding rates.

TABLE 2.—*Estimated annual yields per acre of crops and pasture under high level management*

[Absence of yield figure indicates that crop is not commonly grown on the soil at the level of management specified or is not suited to the soil. Only arable soils are listed]

Soil	Wheat	Oats	Barley	Cotton lint	Grain sorghum	Irrigated peanuts	Alfalfa hay	Improved bermuda grass	Weeping lovegrass
	Bu	*Bu*	*Bu*	*Lb*	*Bu*	*Lb*	*Tons*	*AUM*[1]	*AUM*[1]
Bethany silt loam, 0 to 1 percent slopes	35	60	55	450	55		3. 5	7. 0	7. 0
Binger fine sandy loam, 1 to 5 percent slopes	20	35	30	300	35	2, 000		6. 0	6. 0
Brewer silty clay loam	35	60	55	450	60		4. 5	8. 0	8. 0
Brewer-Drummond complex	20	30	30	275	30			7. 0	
Canadian fine sandy loam	30	55	50	475	50	3, 400	4. 0	7. 5	8. 0
Dale silt loam	35	60	55	500	60		4. 5	8. 5	8. 0
Darnell-Noble complex, 1 to 8 percent slopes								4. 0	4. 0
Dill-Quinlan complex, 5 to 8 percent slopes	15	25	20					5. 0	5. 5
Gracemore loamy fine sand, occasionally flooded	20	35	30		35		3. 0	7. 0	6. 5
Gracemore soils, frequently flooded								6. 5	
Grandfield fine sandy loam, 1 to 3 percent slopes	25	40	35	375	45	3, 200	2. 5	6. 5	6. 5
Grandfield fine sandy loam, 3 to 5 percent slopes	20	35	30	325	35	2, 900		5. 5	6. 0
Grandfield fine sandy loam, 2 to 6 percent slopes, eroded	15	25	20					5. 0	5. 0
Grandfield fine sandy loam, 5 to 8 percent slopes	15	25	20					4. 5	5. 0
Grandfield soils, 3 to 8 percent slopes, severely eroded								4. 5	4. 5

See footnote at end of table.

TABLE 2.—*Estimated annual yields per acre of crops and pasture under high level management*—Continued

Soil	Wheat	Oats	Barley	Cotton lint	Grain sorghum	Irrigated peanuts	Alfalfa hay	Improved bermuda grass	Weeping lovegrass
	Bu	*Bu*	*Bu*	*Lb*	*Bu*	*Lb*	*Tons*	*AUM*[1]	*AUM*[1]
Grant-Hinkle complex, 1 to 3 percent slopes	20	30	30	250	30			5.5	
Grant-Port complex, 0 to 12 percent slopes								5.5	5.5
Grant-Quinlan complex, 5 to 8 percent slopes	20	30	25		30			5.0	5.0
Grant-Quinlan complex, 3 to 8 percent slopes, eroded	15	25	20					4.5	4.0
Kingfisher silt loam, 1 to 3 percent slopes	30	45	40	375	45		2.0	6.0	6.0
Kingfisher silt loam, 3 to 5 percent slopes	25	40	35	325	35			6.0	6.0
Kirkland silt loam, 0 to 1 percent slopes	30	55	50	350	40			5.5	5.5
Kirkland silt loam, 1 to 3 percent slopes	25	45	40	300	35			5.0	5.0
Kirkland-Hinkle complex, 0 to 3 percent slopes	20	35	35		25			4.5	
Konawa loamy fine sand, 3 to 8 percent slopes	20	35	30			2,500		5.5	6.0
McLain silty clay loam	35	60	55	450	60		4.5	8.5	8.5
Minco very fine sandy loam, 5 to 8 percent slopes	20	35	30					6.0	6.0
Minco very fine sandy loam, 8 to 30 percent slopes								4.5	4.5
Minco silt loam, 1 to 3 percent slopes	30	45	40	400	45	3,200	2.5	7.0	7.5
Minco silt loam, 3 to 5 percent slopes	25	40	35	350	35	2,850		6.5	7.0
Nash-Quinlan complex, 3 to 8 percent slopes	20	30	25					5.0	5.0
Nash-Quinlan complex, 3 to 8 percent slopes, eroded	15	25	20					4.5	4.5
Nash-Quinlan complex, 3 to 8 percent slopes, severely eroded								4.0	4.0
Noble fine sandy loam, 3 to 5 percent slopes	20	35	30	300	35	2,900		5.5	5.5
Norge silt loam, 1 to 3 percent slopes	30	50	45	400	45	3,200	2.5	7.0	7.5
Norge silt loam, 3 to 5 percent slopes	25	40	35	325	40			6.5	7.0
Norge silt loam, 5 to 8 percent slopes	20	35	30					6.0	6.5
Pond Creek silt loam, 0 to 1 percent slopes	35	55	50	450	55	3,300	3.0	7.5	8.0
Pond Creek silt loam, 1 to 3 percent slopes	30	50	45	400	45	3,200	2.5	7.0	7.5
Port silt loam	35	60	55	500	60		4.5	8.5	8.5
Port soils, frequently flooded								7.5	
Quinlan-Dill complex, 5 to 12 percent slopes								4.0	4.0
Reinach very fine sandy loam	35	60	55	475	60	3,400	4.0	8.5	8.5
Renfrow silt loam, 0 to 1 percent slopes	30	55	50	350	40			5.5	5.5
Renfrow silt loam, 1 to 3 percent slopes	25	45	40	250	35			5.0	5.0
Renfrow clay loam, 2 to 5 percent slopes, eroded	15	25	20					4.5	5.0
Shellabarger fine sandy loam, 1 to 3 percent slopes	25	40	35	375	45	3,200	2.5	6.5	6.5
Shellabarger fine sandy loam, 3 to 5 percent slopes	20	35	30	325	35	2,900		5.5	6.0
Shellabarger fine sandy loam, 5 to 8 percent slopes	15	25	20					5.0	5.5
Shellabarger fine sandy loam, 3 to 8 percent slopes, eroded	15	25	20					5.0	5.5
Shellabarger-Albion complex, 5 to 12 percent slopes								4.0	4.5
Vernon clay loam, 3 to 5 percent slopes	15	25	20		15			3.5	4.0
Vernon soils, 3 to 5 percent slopes, eroded									3.5
Watonga silty clay	30	50	45	400	50		3.5	7.0	
Yahola fine sandy loam	30	50	45	400	50	3,300	3.5	7.5	7.5

[1] AUM: Animal-unit-month is a term used to express the carrying capacity of pasture. It is the number of months during a year that 1 acre will provide grazing for 1 animal.

Range [3]

This section contains information about the use of soils for range. Range is land on which the natural plant community is chiefly grass, grasslike plants, forbs, and shrubs that are suitable for grazing and are present in sufficient quantity to justify such use. About 40 percent of the acreage in Canadian County is native range. The range is usually grazed year long. Small grain and forage sorghum are used to supplement the stocker-feeder and cow-calf operations.

Range sites and condition classes

Different kinds of soil vary in their capacity to produce grass and other plants for grazing. Soils that produce about the same kinds and amounts of forage, if the range is in similar condition, make up a range site.

Range sites are kinds of range that differ in their ability to produce vegetation. The soils of any one range site produce about the same kind of climax vegetation. Climax

[3] By DAVID L. ANKLE, range conservationist, Soil Conservation Service.

vegetation is the stabilized plant community; it reproduces itself and does not change, so long as the environment remains unchanged. Throughout the prairie and the plains, the climax vegetation consists of the plants that were growing there when the region was first settled. If cultivated crops are not grown, the most productive combination of forage plants on a range site is generally the climax vegetation.

Decreasers are plants in the climax vegetation that tend to decrease in relative amount under close grazing. They generally are the tallest and most productive perennial grasses and forbs and the most palatable to livestock.

Increasers are plants in the climax vegetation that increase in relative amount as the more desirable decreaser plants are reduced by close grazing. They are commonly shorter than decreasers and are generally less palatable to livestock.

Invaders are plants that cannot compete with plants in the climax plant community for moisture, nutrients, and light. Hence, invaders come in and grow along with increasers after the climax vegetation has been reduced by grazing. Many invaders are annual weeds, some are shrubs that have some grazing value, and others have little value for grazing.

Four range condition classes are used to indicate the degree of departure from the potential, or climax, vegetation brought about by grazing or other uses. The classes show the present condition of the native vegetation on a range site in relation to the native vegetation that could grow there.

A range is in *excellent* condition if 76 to 100 percent of the vegetation is of the same kind as that in the climax stand. It is in *good* condition if the percentage is 51 to 75; in *fair* condition if the percentage is 26 to 50; and in *poor* condition if the percentage is 25 or less.

Range condition is judged according to standards that apply to the particular range site. It expresses the present kind and amount of vegetation in relation to the climax plant community for that site. Potential forage production depends on the range site. Current forage production depends on the range condition and the moisture available to plants during their growing season.

A primary objective of good range management is to keep range in excellent or good condition. If this is done, water is conserved, yields are improved, and the soils are protected. The main concern of management is recognizing important changes in the kind of cover on a range site. These changes take place gradually and can be misinterpreted or overlooked. Growth encouraged by heavy rainfall may lead to the conclusion that the range is in good condition, when actually the cover is weedy and the long-term trend is toward lower production. On the other hand, some range that has been closely grazed for short periods, under the supervision of a careful manager, may have a degraded appearance that temporarily conceals its quality and ability to recover.

Descriptions of range sites

In the following pages the soils on range sites of Canadian County are described and the climax plants and principal invaders on the sites are named. Also given is an estimate of the potential annual yield of air-dry herbage for each site if it is in excellent condition. The soils in each site can be determined by referring to the "Guide to Mapping Units" at the back of this survey.

BREAKS RANGE SITE

This site is on uplands. The soils are shallow and moderately steep to steep. They have a loamy surface layer and a loamy subsoil.

If this site is in excellent condition, the climax plant community is about 25 percent little bluestem, 15 percent big bluestem, 10 percent indiangrass, 15 percent side-oats grama, and 5 percent each of hairy grama, blue grama, prairie-clover, trailing ratany, Louisiana sagewort, woody plants, and other plants.

Under continuous heavy grazing, the bluestems, indiangrass, prairie-clover, and trailing ratany decrease and such plants as side-oats grama, hairy grama, blue grama, Louisiana sagewort, big bluets, skunkbush, and oak increase. If overgrazing is prolonged, the site is invaded by oldfield three-awn, puffsheath dropseed, silver bluestem, western ragweed, and eastern redcedar and total production is greatly reduced.

If this site is in excellent condition, it produces 1,800 pounds of air-dry herbage per acre in years when growing conditions are favorable and 1,200 pounds when they are unfavorable.

The range management practical on this site consists of proper grazing use and deferred grazing and provision for stockwater ponds.

CLAYPAN PRAIRIE RANGE SITE

This site is on uplands. The soils are deep and nearly level to gently sloping. They have a loamy surface layer and a clayey subsoil.

If this site is in excellent condition, the climax plant community is 25 percent little bluestem, 20 percent big bluestem, 15 percent switchgrass, 10 percent indiangrass, and 5 percent each of side-oats grama, blue grama, buffalograss, leadplant, goldenrod, and coralberry.

Under continuous heavy grazing, the bluestems, switchgrass, indiangrass, leadplant, and Illinois bundleflower decrease and such plants as side-oats grama, blue grama, buffalograss, goldenrod, and coralberry increase. If overgrazing is prolonged, the site is invaded by three-awn, silver bluestem, ragweed, and common broomweed and total production is greatly reduced.

If this site is in excellent condition, it produces 3,500 pounds of air-dry herbage per acre in years when growing conditions are favorable and 1,800 pounds when they are unfavorable.

The range management practical on this site consists of proper grazing use and deferred grazing, a planned grazing system, range seeding, fencing, provision for stockwater ponds, and brush and weed management.

DEEP SAND SAVANNAH RANGE SITE

This site is on uplands. The soil, Konawa loamy fine sand, 3 to 8 percent slopes, is deep and gently sloping to sloping. It has a sandy surface layer and a loamy subsoil.

If this site is in excellent condition, the climax plant community is 25 percent little bluestem, 20 percent sand bluestem, 20 percent woody plants, and 5 percent each of indiangrass, switchgrass, purpletop, three-awn, Scribner panicum, side-oats grama, and perennial lespedeza.

Under continuous heavy grazing, little bluestem, sand bluestem, indiangrass, switchgrass, and perennial lespedeza decrease and such plants as purpletop, arrowfeather three-awn, Scribner panicum, side-oats grama, post oak, blackjack oak, and hickory increase. If overgrazing is

prolonged, the site is invaded by sand dropseed, broomsedge bluestem, three-awn, annual brome, ragweed, eastern redcedar, and skunkbush and total production is decreased.

If this site is in excellent condition, it produces 3,800 pounds of air-dry herbage per acre in years when growing conditions are favorable and 1,800 pounds when they are unfavorable.

The range management practical on this site consists of proper grazing use and deferred grazing, a planned grazing system, range seeding, fencing, provision for stockwater ponds, and brush and weed management.

DUNE RANGE SITE

This site is on uplands. The soil, Tivoli fine sand, is deep and strongly sloping to moderately steep. It has a sandy surface layer and a sandy subsoil.

If this site is in excellent condition, the climax plant community is 25 percent little bluestem, 20 percent sand bluestem, 10 percent big sandreed, 10 percent Texas bluegrass, and 5 percent each of sand lovegrass, Scribner panicum, sand dropseed, perennial lespedeza, Illinois bundleflower, bigtop dalea, and woody plants.

Under continuous heavy grazing, little bluestem, sand bluestem, sand lovegrass, big sandreed, Illinois bundleflower, and perennial lespedeza decrease and such plants as Texas bluegrass, sand dropseed, Scribner panicum, bigtop dalea, skunkbush, and sandplum increase. If overgrazing is prolonged the site is invaded by annual brome, mat sandbur, showy partridgepea, nightshades, wild buckwheat, and skunkbush and total production is decreased.

If this site is in excellent condition, it produces 2,000 pounds of air-dry herbage per acre in years when growing conditions are favorable and 1,200 pounds when they are unfavorable.

The range management practical on this site consists of proper grazing use and deferred grazing, range seeding, fencing, provision for stockwater ponds, and brush and weed management.

ERODED PRAIRIE RANGE SITE

This site is on uplands. The soils are deep, moderately deep, and shallow, gently sloping to sloping, and severely eroded. They have a loamy and sandy surface layer and a loamy subsoil.

If this site is in excellent condition, the climax plant community is 35 percent little bluestem, 10 percent big or sand bluestem, 10 percent side-oats grama, 10 percent tall dropseed, and 5 percent each of indiangrass, switchgrass, blue grama, prairie-clover, perennial sunflower, heath aster, and woody plants.

Under continuous heavy grazing, little bluestem, big or sand bluestem, switchgrass, indiangrass, prairie-clover, and perennial sunflower decrease and such plants as side-oats grama, tall dropseed, blue grama, heath aster, coralberry, and sumacs increase. If overgrazing is prolonged, the site is invaded by splitbeard and silver bluestem, three-awn, annual brome, ragweed, yarrow, and persimmon and total production is greatly reduced.

If this site is in excellent condition, it produces 2,400 pounds of air-dry herbage per acre in years when growing conditions are favorable and 1,100 pounds when they are unfavorable.

The range management practical on this site consists of proper grazing use and deferred grazing, range seeding, a planned grazing system, provision for stockwater ponds, fencing, and brush and weed management.

HEAVY BOTTOMLAND RANGE SITE

This site is on flood plains. The soils are deep and nearly level. They have a loamy or clayey surface layer and a loamy or clayey subsoil.

If this site is in excellent condition, the climax plant community is 25 percent big bluestem, 15 percent switchgrass, 15 percent indiangrass, 10 percent prairie cordgrass, 10 percent woody plants, and 5 percent each of western wheatgrass, tall dropseed, perennial sunflower, goldenrod, and sedge.

Under continuous heavy grazing, big bluestem, switchgrass, indiangrass, prairie cordgrass, and perennial sunflower decrease and such plants as western wheatgrass, tall dropseed, goldenrod, sedge, pecan, ash, and sumac increase. If overgrazing is prolonged, the site is invaded by barnyardgrass, annual bromes, silver bluestem, seacoast sumpweed, ragweed, ironweed, and persimmon and total production is greatly reduced.

If this site is in excellent condition, it produces 5,500 pounds of air-dry herbage per acre in years when growing conditions are favorable and 2,500 pounds when they are unfavorable.

The range management practical on this site consists of proper grazing use and deferred grazing, a planned grazing system, provision for stockwater ponds, cross-fencing, and brush and weed management.

LOAMY BOTTOMLAND RANGE SITE

This site is on flood plains. The soils are deep and nearly level. They have a loamy surface layer and a loamy subsoil.

If this site is in excellent condition, the climax plant community is 25 percent big bluestem, 15 percent indiangrass, 15 percent switchgrass, 10 percent little bluestem, and 5 percent each of eastern gamagrass, tall dropseed, beaked panicum, compass plant, heath aster, sedge, and woody plants.

Under continuous heavy grazing, big bluestem, indiangrass, switchgrass, little bluestem, eastern gamagrass, and compass plant decrease and such plants as tall dropseed, beaked panicum, sedge, heath aster, elm, pecan, walnut, and greenbrier increase. If overgrazing is prolonged, the site is invaded by annual brome, broomsedge bluestem, three-awn, ragweed, ironweed, and white snakeroot and total production is greatly reduced.

If this site is in excellent condition, it produces 8,500 pounds of air-dry herbage per acre in years when growing conditions are favorable and 4,500 pounds when they are unfavorable.

The range management practical on this site consists of proper grazing use and deferred grazing, a planned grazing system, provision for stockwater ponds, cross-fencing, range seeding, and brush and weed management.

LOAMY PRAIRIE RANGE SITE

This site is on uplands. The soils are deep and moderately deep and nearly level to steep. They have a loamy surface layer and a loamy and clayey subsoil.

If this site is in excellent condition, the climax plant community is 25 percent little bluestem, 20 percent big

bluestem, 10 percent indiangrass, 10 percent switchgrass, and 5 percent each of Canada wildrye, side-oats grama, blue grama, tall dropseed, perennial lespedeza, dotted gayfeather, and woody plants.

Under continuous heavy grazing little bluestem, big bluestem, indiangrass, switchgrass, Canada wildrye, and perennial lespedeza decrease and such plants as side-oats grama, blue grama, tall dropseed, dotted gayfeather, smooth sumac, and plum increase. If overgrazing is prolonged, the site is invaded by silver bluestem, annual brome, three-awn, common broomweed, western ragweed, and yarrow and total production is greatly reduced.

If this site is in excellent condition, it produces 5,000 pounds of air-dry herbage per acre in years when growing conditions are favorable and 2,500 pounds when they are unfavorable.

The range management practical on this site consists of proper grazing use and deferred grazing, a planned grazing system, provision for stockwater ponds, fencing, range seeding, and brush and weed management.

RED CLAY PRAIRIE RANGE SITE

This site is on uplands. The soils are moderately deep and gently sloping to moderately steep. They have a clayey or loamy surface layer and a clayey subsoil.

If this site is in excellent condition, the climax plant community is 30 percent little bluestem, 15 percent big bluestem, 10 percent side-oats grama, and 5 percent each of switchgrass, indiangrass, blue grama, hairy grama, buffalograss, tall dropseed, prairie-clover, blacksamson, and woody plants.

Under continuous heavy grazing, little bluestem, big bluestem, switchgrass, indiangrass, prairie-clover, and blacksamson decrease and such plants as side-oats grama, blue grama, hairy grama, buffalograss, tall dropseed, and smooth sumac increase. If overgrazing is prolonged, the site is invaded by Japanese brome, windmillgrass, three-awn, showy partridgepea, common broomweed, ragweed, broom snakeweed, and coralberry and total production is greatly reduced.

If this site is in excellent condition, it produces 2,700 pounds of air-dry herbage per acre in years when growing conditions are favorable and 1,600 pounds when they are unfavorable.

The range management practical on this site consists of proper grazing use and deferred grazing, a planned grazing system, provision for stockwater ponds, fencing, range seeding, and brush management.

SALINE SUBIRRIGATED RANGE SITE

This site is on uplands. The soils are deep and nearly level. They have a loamy surface layer and a loamy subsoil that is affected by sodium.

If this site is in excellent condition, the climax plant community is 25 percent switchgrass, 15 percent little bluestem, 10 percent indiangrass, 10 percent alkali sacaton, and 5 percent each of inland saltgrass, tall dropseed, western wheatgrass, vine-mesquite, perennial sunflower, Illinois bundleflower, sedge, and woody plants.

Under continuous heavy grazing, switchgrass, little bluestem, indiangrass, western wheatgrass, vine-mesquite, Illinois bundleflower, and perennial sunflower decrease and such plants as alkali sacaton, inland saltgrass, tall dropseed, sedge, willow, baccharis, and indigobush increase. If overgrazing is prolonged, the site is invaded by saltcedar, cottonwood, windmillgrass, ironweed, western ragweed, and annual bromes and total production is greatly reduced.

If this site is in excellent condition, it produces 7,000 pounds of air-dry herbage per acre in years when growing conditions are favorable and 5,000 pounds when they are unfavorable.

The range management practical on this site consists of proper grazing use and deferred grazing, a planned grazing system, provision for stockwater ponds and cattle walkways, range seeding, and brush and weed management.

SANDY PRAIRIE RANGE SITE

This site is on uplands. The soils are deep and moderately deep and very gently sloping to strongly sloping. They have a loamy surface layer and a loamy subsoil.

If this site is in excellent condition (fig. 4), the climax plant community is 30 percent little bluestem, 15 percent sand bluestem, 10 percent switchgrass, 10 percent indiangrass, and 5 percent each of Scribner panicum, sand paspalum, side-oats grama, prairie-clover, halfshrub sundrop, yucca, and woody plants.

Under continuous heavy grazing, little bluestem, sand bluestem, switchgrass, indiangrass, halfshrub sundrop, and prairie-clover decrease and such plants as Scribner panicum, sand paspalum, side-oats grama, yucca, smooth sumac, skunkbush, and coralberry increase. If overgrazing is prolonged, the site is invaded by sand dropseed, stinkgrass, windmillgrass, sandbur, croton, nightshade, oak, and western soapberry and total production is greatly reduced.

If this site is in excellent condition, it produces 4,500 pounds of air-dry herbage per acre in years when growing conditions are favorable and 2,000 pounds when they are unfavorable.

The range management practical on this site consists of proper grazing use and deferred grazing, a planned grazing system, provision for stockwater ponds, fencing, range seeding, and brush and weed management.

SANDY SAVANNAH RANGE SITE

This site is on uplands. The soils are deep and very gently sloping to steep. They have a loamy surface layer and a loamy subsoil.

If this site is in excellent condition, the climax plant community is 25 percent little bluestem, 20 percent big bluestem, 15 percent woody plants, and 5 percent each of indiangrass, switchgrass, sand lovegrass, Scribner panicum, purpletop, tall dropseed, perennial sunflower, and goldenrod.

Under continuous heavy grazing, little bluestem, big bluestem, indiangrass, switchgrass, sand lovegrass, and perennial sunflower decrease and such plants as Scribner panicum, purpletop, tall dropseed, goldenrod, post oak, blackjack oak, and hickory increase. If overgrazing is prolonged, the site is invaded by broomsedge bluestem, three-awn, horseweed fleabane, croton, hawthorn, and eastern redcedar and total production is greatly reduced.

If this site is in excellent condition, it produces 4,500 pounds of air-dry herbage per acre in years when growing conditions are favorable and 2,500 pounds when they are unfavorable.

The range management practical on this site consists of proper grazing use and deferred grazing, a planned grazing

Figure 4.—**Sandy Prairie range site. The soil is Shellabarger fine sandy loam, 3 to 5 percent slopes.**

system, provision for stockwater ponds, fencing, rango seeding, and brush and weed management.

SHALLOW PRAIRIE RANGE SITE

This site is on uplands. The soils are shallow and gently sloping to steep. They have a loamy surface layer and a loamy subsoil.

If this site is in excellent condition, the climax plant community is 30 percent little bluestem, 15 percent big bluestem, 10 percent indiangrass, 10 percent switchgrass, 10 percent tall dropseed, and 5 percent each of Scribner panicum, side-oats grama, prairie-clover, dotted gayfeather, and woody plants.

Under continuous heavy grazing, little bluestem, big bluestem, switchgrass, indiangrass, and prairie-clover decrease and such plants as Scribner panicum, side-oats grama, tall dropseed, dotted gayfeather, smooth sumac, coralberry, and blackberry increase. If overgrazing is prolonged, the site is invaded by three-awn, ragweed, yarrow, bitter sneezeweed, persimmon, and oak and total production is greatly reduced.

If this site is in excellent condition, it produces 3,000 pounds of air-dry herbage per acre in years when growing conditions are favorable and 1,500 pounds when they are unfavorable.

The range management practical on this site consists of proper grazing use, a planned grazing system, provision for stockwater ponds, range seeding, and brush and weed management.

SHALLOW SAVANNAH RANGE SITE

This site is on uplands. The soils are shallow and very gently sloping to steep. They have a loamy surface layer and a loamy subsoil.

If this site is in excellent condition, the climax plant community is 30 percent little bluestem, 20 percent big or sand bluestem, 15 percent woody plants, and 5 percent each of indiangrass, switchgrass, side-oats grama, purpletop, Scribner panicum, tall dropseed, and hairy sunflower.

Under continuous heavy grazing, little bluestem, big or sand bluestem, indiangrass, switchgrass, and hairy sunflower decrease and such plants as side-oats grama, purpletop, Scribner panicum, tall dropseed, post oak, blackjack oak, and hickory increase. If overgrazing is prolonged, the site is invaded by broomsedge bluestem, puffsheath dropseed, blackeyed susan, common witchgrass, elm, eastern

redcedar, and Ohio buckeye and total production is greatly reduced.

If this site is in excellent condition, it produces 2,800 pounds of air-dry herbage per acre in years when growing conditions are favorable and 1,400 pounds when they are unfavorable.

The range management practical on this site consists of proper grazing use, a planned grazing system, provision for stockwater ponds, range seeding, and brush and weed management.

SLICKSPOT RANGE SITE

This site is on uplands. The soils are deep and nearly level to very gently sloping. They have a loamy surface layer and a clayey or loamy subsoil that is high in content of sodium.

If this site is in excellent condition, the climax plant community is 25 percent blue grama, 15 percent little bluestem, 10 percent western wheatgrass, 10 percent tall dropseed, 10 percent white tridens, 10 percent silver bluestem, and 5 percent each of side-oats grama, fall witchgrass, buffalograss, and dotted gayfeather.

Under continuous heavy grazing, little bluestem, western wheatgrass, tall dropseed, white tridens, and dotted gayfeather decrease and such plants as blue grama, silver bluestem, fall witchgrass, side-oats grama, and buffalograss increase. If overgrazing is prolonged, the site is invaded by annual brome, windmillgrass, tumblegrass, three-awn, deer vetch, and pricklypear cactus and total production is greatly reduced.

If this site is in excellent condition, it produces 1,800 pounds of air-dry herbage per acre in years when growing conditions are favorable and 800 pounds when they are unfavorable.

The range management practical on this site consists of proper grazing use, a planned grazing system, provision for stockwater ponds, range seeding, and brush and weed management.

SUBIRRIGATED RANGE SITE

This site is on flood plains. The soils are deep and nearly level. They have a sandy and loamy surface layer, a sandy subsoil, and a high water table.

If this site is in excellent condition, the climax plant community is 25 percent switchgrass, 20 percent sand or big bluestem, 10 percent indiangrass, 10 percent eastern gamagrass, 10 percent beaked panicum, and 5 percent each of wildrye, Scribner panicum, purpletop, maximilian sunflower, and woody plants.

Under continuous heavy grazing, switchgrass, sand bluestem, big bluestem, indiangrass, eastern gamagrass, wildrye, and maximilian sunflower decrease and such plants as Scribner panicum, purpletop, beaked panicum, cottonwood, and willow increase. If overgrazing is prolonged, the site is invaded by johnsongrass, annual brome, broomsedge bluestem, showy partridgepea, ragweed, ironweed, and saltcedar and total production is greatly reduced.

If this site is in excellent condition, it produces 10,000 pounds of air-dry herbage per acre in years when growing conditions are favorable and 7,000 pounds when they are unfavorable.

The range management practical on this site consists of proper grazing use and deferred grazing, a planned grazing system, range seeding, provision for stockwater ponds, cross-fencing, and brush and weed management.

Trees [4]

This section contains information on suitability of the soils of Canadian County for trees. Natural stands occur mostly along the rivers and their tributaries and on a few soils in the western part of the county. Some of the trees and shrubs native to this county are American elm, American plum, black locust, blackjack oak, black walnut, bur oak, eastern cottonwood, eastern redcedar, green ash, hackberry, honeylocust, pecan, post oak, willow, and tamarisk. Some of the trees and shrubs recommended for planting are introduced from other areas.

Except for watershed, wildlife habitat, and esthetic purposes, natural stands have only limited economic value. Early settlers planted trees for protection (fig. 5), shade, and fenceposts.

Planting of trees.—Preparation for tree planting can be the same as for ordinary field crops on most soils. Many of the species used are native to the county but do not grow naturally where trees are needed. Soils that are not sandy can be prepared far enough in advance to have time to settle. Alfalfa and grass sod should be summer fallowed at least 1 year before planting, and cropland should be fall plowed.

Sandy soils should be planted without any advance preparation, or a cover crop could be planted. Cover crops protect the soil before planting and protect the young seedlings after planting.

The soils of Canadian County that have similar characteristics that affect tree growth have been placed in tree groups. The recommended trees and shrubs in each tree group are indicated. Trees and shrubs are to be planted late in winter or early in spring, and the seedlings need to be protected from drying out while they are being planted. The soil should be packed firm around the roots. Young trees need special care. Weeds need to be controlled and trees protected from livestock and fire.

Following are brief descriptions of the soils in each tree group and the trees and shrubs suitable for planting. To find the tree group of a specific soil, refer to the "Guide to Mapping Units."

TREE GROUP 1

This group consists of deep, somewhat poorly drained, nearly level soils on flood plains. These soils have a high water table most of the year. The surface layer is coarse textured to fine textured and is underlain by coarse-textured sediments.

These soils are suited to trees and shrubs that tolerate wetness and flooding. Suitable for planting are eastern cottonwood, eastern redcedar, green ash, hackberry, loblolly pine, osageorange, sandbar willow, and sycamore. At 20 years of age the estimated height of eastern cottonwood is 85 feet and green ash 65 feet.

TREE GROUP 2

This group consists of deep, well-drained, nearly level soils on flood plains. These soils are moderately coarse textured throughout.

These soils are suitable for trees and shrubs that tolerate flooding. Suitable for planting are American plum, Austrian pine, autumn-olive, eastern cottonwood, eastern redcedar, honeylocust, loblolly pine, northern catalpa,

[4] By NORMAN E. SMOLA, forester, Soil Conservation Service.

Figure 5.—**Farmstead windbreak on Canadian fine sandy loam.**

osageorange, Scotch pine, shortleaf pine, and sycamore. At 20 years of age the estimated height of Austrian pine is 30 feet, eastern cottonwood 65 feet, eastern redcedar 30 feet, loblolly pine 40 feet, and shortleaf pine 35 feet.

TREE GROUP 3

This group consists of deep, well-drained, nearly level soils on flood plains. These soils are medium textured to moderately fine textured throughout.

These soils are good for trees and shrubs that tolerate flooding. Suitable for planting are American plum, Austrian pine, autumn-olive, bur oak, black walnut, eastern cottonwood, eastern redcedar, green ash, hackberry, honeylocust, loblolly pine, northern catalpa, osageorange, pecan, Scotch pine, shortleaf pine, and sycamore. At 20 years of age the estimated height of Austrian pine is 35 feet, eastern cottonwood 75 feet, eastern redcedar 35 feet, green ash 55 feet, loblolly pine 45 feet, and shortleaf pine 40 feet.

TREE GROUP 4

This group consists of deep, well-drained to somewhat poorly drained, nearly level soils on flood plains. The surface layer is medium textured to fine textured, and the subsoil is fine textured to moderately fine textured.

These soils are good for trees and shrubs that tolerate surface wetness and flooding. Suitable for planting are American elm, bur oak, eastern cottonwood, eastern redcedar, green ash, hackberry, honeylocust, osageorange, pecan, shortleaf pine, and sycamore. At 20 years of age the estimated height of eastern cottonwood is 65 feet, eastern redcedar 25 feet, green ash 40 feet, and osageorange 25 feet.

TREE GROUP 5

This group consists of deep, well drained to moderately well drained, nearly level to gently sloping soils on uplands. The surface layer is medium textured to moderately fine textured, and the subsoil is fine textured to moderately fine textured.

These soils are suited to trees and shrubs if weeds and grasses are controlled. Suitable for planting are eastern redcedar, hawthorn, and osageorange. At 20 years of age the estimated height of eastern redcedar is 20 feet.

TREE GROUP 6

Tivoli fine sand is the only soil in this group. It is a deep, excessively drained, strongly sloping to moderately steep soil on uplands. This soil is sandy throughout.

This soil is suited to trees and shrubs if weeds and grasses are controlled. Suitable for planting are American plum, eastern redcedar, osageorange, Scotch pine, and shortleaf pine. At 20 years of age the estimated height of redcedar is 22 feet.

TREE GROUP 7

This group consists of typically deep to moderately deep, well-drained, nearly level to strongly sloping soils on uplands. The surface layer is moderately coarse textured to medium textured, and the subsoil is moderately coarse textured to fine textured. Also in this group are small areas of moderately steep to steep soils that have a coarse-textured to moderately fine textured surface ayer.

These soils are suited to trees and shrubs if weeds and grasses are controlled. Suitable for planting are American plum, Austrian pine, autumn-olive, bur oak, eastern cottonwood, eastern redcedar, hackberry, honeylocust, loblolly pine, northern catalpa, osageorange, Scotch pine, shortleaf pine, and sycamore. At 20 years of age the estimated height of Austrian pine is 30 feet, eastern cottonwood 65 feet, eastern redcedar 30 feet, loblolly pine 40 feet, and shortleaf pine 35 feet.

TREE GROUP 8

This group consists of typically shallow to moderately deep, somewhat excessively drained to well-drained, very gently sloping to strongly sloping soils on uplands. These soils are moderately coarse textured to medium textured throughout. Also in this group are small areas of soils that are moderately fine textured to fine textured throughout, are moderately steep to steep, or are deep.

These soils are suited to a few species of trees and shrubs. Trees planted on these soils suffer from a shortage of moisture. Suitable for planting are black locust, eastern redcedar, hawthorn, osageorange, and shortleaf pine. Hackberry and honeylocust are also suited on soils that are moderately fine textured to fine textured. At 20 years of age the estimated height of eastern redcedar is 18 feet.

TREE GROUP 9

This group consists of typically deep to shallow, severely eroded, well-drained, gently sloping to sloping soils on uplands. The surface layer is medium textured to coarse textured, and the subsoil is medium textured to moderately fine textured. Also in this group are shallow to moderately deep, uneroded, well-drained, moderately steep to steep soils that are fine textured to medium textured throughout.

These soils are suited to a few species of trees and shrubs. Planting is not recommended on these soils because of severe erosion and steepness.

Wildlife Habitat [5]

This section contains information about the suitability of the soils of Canadian County for wildlife habitat. Soils directly influence the kinds and amount of vegetation and the amount of water available; and in this way, they influence the kinds of wildlife that can live in an area. Soil properties that affect the growth of wildlife habitat are: (1) thickness of soil useful to crops, (2) surface texture, (3) available water capacity, (4) wetness, (5) hazard of flooding, (6) slope, and (7) permeability of the soil to air and water.

[5] By JEROME F. SYKORA, biologist, Soil Conservation Service.

In table 3 the soils of Canadian County are rated for suitability for six elements of wildlife habitat and for three groups, or kinds, of wildlife. A rating of *good* means that the element of wildlife habitat and kinds of habitat generally are easily created, improved, and maintained. Few or no limitations affect management in this category, and satisfactory results are expected where the soil is used for the prescribed purpose. A rating of *fair* means that the element of wildlife habitat and kinds of habitat can be created, improved, and maintained in most places. A moderate intensity of management and fairly frequent attention may be required for satisfactory results. A rating of *poor* means that the elements of wildlife habitat and limitations for the designated use are severe. Habitat can be created, improved, and maintained in most places, but management is difficult and requires intensive effort. A rating of *very poor* means that the elements of wildlife habitat have very severe limitations and unsatisfactory results are to be expected. It is impractical to create, improve, or maintain habitat on soils in this category.

Each soil is rated in table 3 according to its suitability for producing various kinds of plants and other elements that make up wildlife habitat. The ratings mainly take into account the characteristics of the soils and closely related natural factors of the environment. They do not take into account climate, present use of the soils, or present distribution of wildlife and people. For this reason, selection of a site for development as habitat for wildlife requires onsite inspection. The habitat elements rated in table 3 are as follows:

Grain and seed crops are annual grain-producing plants, such as wheat, sorghum, millet, and soybeans.

Grasses and legumes are domestic species established by planting. They provide food and cover for wildlife. Grasses include bermudagrass and weeping lovegrass. Legumes include alfalfa, clovers, peas, and lespedezas.

Wild herbaceous plants are native grasses, forbs, legumes, and weeds that provide food and cover for wildlife. Grasses include bluestems, switchgrass, other panicums, foxtail, wildryes, wild buckwheats, and annual bromes. Legumes include lespedezas, wild beans, Illinois bundleflower, tickclovers, and scurfpeas. Forbs and weeds include croton, sunflower, ragweed, pigweed, pokeweed, nightshades, queensdelight, black sampson, and prickle-poppy.

Shrubs include shrubs, conifers, and woody vines that provide wildlife food in the form of fruits, nuts, buds, catkins, or browse. Such plants commonly grow in their natural environment, but they may be planted. Typical species in this category are American plum, chittamwood, skunkbush sumac, greenbrier, roughleaf dogwood, poison-ivy, and redcedar.

Wetland plants are herbaceous plants that grow wild on moist and wet sites. They furnish food and cover mostly for wetland wildlife. Typical wetland plants are smartweed, wild millet, rushes, barnyardgrass, and sedges.

Shallow water areas are impoundments or excavations for controlling water, generally no more than 5 feet deep, to create habitat suitable for waterfowl. Some are designed to be drained, planted, and then flooded; others are permanent impoundments that grow submerged aquatics.

Table 3 also rates soils according to their suitability as habitat for the three kinds of wildlife in the county—openland, wetland, and rangeland wildlife. These ratings

TABLE 3.—*Wildlife habitat*

[Ratings apply only to the series named. For other soils in a mapping unit, refer to the appropriate series]

Soil series and map symbols	Potential for habitat elements						Potential for kinds of wildlife		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Shrubs	Wetland plants	Shallow water areas	Openland	Wetland	Rangeland
Albion Mapped only with Shellabarger soils.	Fair	Good	Good	Fair	Very poor.	Very poor.	Good	Very poor.	Fair.
Bethany: BeA	Good	Good	Good	Fair	Poor	Very poor.	Good	Very poor.	Fair.
Binger: BnC	Fair	Good	Good	Fair	Poor	Very poor.	Good	Very poor.	Fair.
Brewer: Br, Bu	Good	Good	Fair	Fair	Poor	Poor	Good	Poor	Fair.
Canadian: Ca	Good	Good	Good	Good	Poor	Very poor.	Good	Very poor.	Good.
Dale: Da	Good	Good	Good	Good	Poor	Very poor.	Good	Very poor.	Good.
Darnell: DnD, DnF	Poor	Poor	Fair	Fair	Very poor.	Very poor.	Poor	Very poor.	Fair.
Dill: DuD	Fair	Good	Good	Fair	Poor	Very poor.	Good	Very poor.	Fair.
Drummond Mapped only with Brewer soils.	Poor	Fair	Fair	Poor	Fair	Fair	Fair	Fair	Poor.
Gracemore: Ga	Fair	Fair	Good	Fair	Fair	Poor	Fair	Poor	Fair.
Gb	Poor	Fair	Fair	Fair	Fair	Poor	Fair	Poor	Fair.
Grandfield: GdB, GdC, GdC2, GdD	Good	Good	Good	Fair	Poor	Very poor.	Good	Very poor.	Fair.
GdD3	Fair	Good	Good	Fair	Poor	Very poor.	Good	Very poor.	Fair.
Grant: GhB	Good	Good	Good	Fair	Poor	Very poor.	Good	Very poor.	Fair.
GpE, GuD, GuD2	Fair	Good	Good	Fair	Poor	Very poor.	Good	Very poor.	Fair.
Hinkle Mapped only with Grant and Kirkland soils.	Poor	Poor	Very poor.	Very poor.	Very poor.	Poor	Poor	Very poor.	Very poor.
Kingfisher: KfB, KfC	Fair	Good	Good	Fair	Poor	Very poor.	Good	Very poor.	Fair.
Kirkland: KrA, KrB, KsB	Good	Good	Good	Fair	Poor	Very poor.	Good	Very poor.	Fair.
Konawa: KwD	Fair	Good	Good	Fair	Poor	Very poor.	Good	Very poor.	Fair.
McLain: Mc	Good	Good	Fair	Fair	Poor	Poor	Good	Poor	Fair.
Minco: MnD	Fair	Good	Good	Good	Poor	Very poor.	Good	Very poor.	Good.
MnF	Poor	Fair	Good	Fair	Very poor.	Very poor.	Fair	Very poor.	Fair.
MsB, MsC	Good	Good	Good	Good	Poor	Very poor.	Good	Very poor.	Good.
Nash: NaD, NaD2	Fair	Good	Good	Fair	Poor	Very poor.	Good	Very poor.	Fair.
NaD3	Poor	Good	Good	Fair	Poor	Very poor.	Fair	Very poor.	Fair.
Noble: DnD	Fair	Good	Good	Good	Poor	Very poor.	Good	Very poor.	Good.
DnF	Poor	Fair	Good	Fair	Very poor.	Very poor.	Fair	Very poor.	Fair.
NbC	Good	Good	Good	Good	Poor	Very poor.	Good	Very poor.	Good.

TABLE 3.—*Wildlife habitat*—Continued

Soil series and map symbols	Potential for habitat elements						Potential for kinds of wildlife		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Shrubs	Wetland plants	Shallow water areas	Openland	Wetland	Rangeland
Norge:									
NrB, NrC	Good	Good	Good	Fair	Poor	Very poor.	Good	Very poor.	Fair.
NrD	Fair	Good	Good	Fair	Poor	Very poor.	Good	Very poor.	Fair.
Pond Creek: PkA, PkB	Good	Good	Good	Fair	Poor	Very poor.	Good	Very poor.	Fair.
Port:									
Po	Good	Good	Good	Good	Poor	Very poor.	Good	Very poor.	Good.
Pw	Poor	Fair	Fair	Good	Poor	Very poor.	Fair	Very poor.	Fair.
Quinlan:									
GuD, GuD2, NaD, NaD2	Poor	Poor	Fair	Poor	Poor	Very poor.	Poor	Very poor.	Poor.
NaD3	Very poor.	Poor	Fair	Poor	Very poor.	Very poor.	Poor	Very poor.	Poor.
QdE, QrF	Poor	Poor	Fair	Poor	Very poor.	Very poor.	Poor	Very poor.	Poor.
Rock outcrop. No interpretations.									
Reinach: Ra	Good	Good	Good	Good	Poor	Very poor.	Good	Very poor.	Good.
Renfrow:									
RbA, RbB	Good	Good	Good	Fair	Poor	Very poor.	Good	Very poor.	Fair.
RcC2	Good	Good	Fair	Fair	Poor	Very poor.	Good	Very poor.	Fair.
Shellabarger:									
ShB, ShC	Good	Good	Good	Good	Poor	Very poor.	Good	Very poor.	Good.
ShD, ShD2	Fair	Good	Good	Good	Poor	Very poor.	Good	Very poor.	Good.
SnE	Fair	Good	Good	Fair	Very poor.	Very poor.	Good	Very poor.	Fair.
Tivoli: Tv	Poor	Poor	Fair	Poor	Very poor.	Very poor.	Poor	Very poor.	Poor.
Vernon:									
VeC	Fair	Good	Fair	Poor	Poor	Very poor.	Fair	Very poor.	Poor.
VrE	Fair	Fair	Poor	Very poor.	Very poor.	Very poor.	Poor	Very poor.	Very poor.
VsC2	Fair	Fair	Poor	Very poor.	Poor	Very poor.	Poor	Very poor.	Very poor.
Watonga: Wa	Fair	Fair	Poor	Fair	Poor	Poor	Fair	Poor	Fair.
Yahola: Ya	Good	Good	Good	Good	Poor	Very poor.	Good	Very poor.	Good.

are related to ratings made for the elements of habitat. For example, soils rated very poor for shallow water developments are rated very poor for wetland wildlife.

Openland wildlife are birds and mammals that normally live in meadows, pastures, and open areas where grasses, herbs, and shrubby plants grow. Quail, doves, meadowlarks, field sparrows, rabbits, and foxes are examples.

Wetland wildlife are birds and mammals that normally live in wet areas, marshes, and swamps. Ducks, geese, rails, shore birds, herons, minks, beaver, and muskrats are examples.

Rangeland wildlife are birds and mammals of natural rangeland. Examples are antelope, white-tailed deer, prairie chicken, chukar, quail, meadowlark, dove, turkey, and squirrel.

Engineering [6]

This section is useful to those who need information about soils used as structural material or as foundation upon which structures are built. Among those who can benefit from this section are planning commissions, town and city managers, land developers, engineers, contractors, and farmers.

Among properties of soils highly important in engineering are permeability, strength, compaction characteristics, soil drainage condition, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth

[6] GEORGE K. SITES, engineer, Soil Conservation Service, helped prepare this section.

to the water table, depth to bedrock, and soil slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soil on which they are built, for the purpose of predicting performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables 4, 5, and 6, which show, respectively, several estimated soil properties significant to engineering, engineering interpretations, and results of engineering laboratory tests on soil samples.

This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in tables 4, 5, and 6, and it also can be used to make other useful maps.

This information, however, does not eliminate the need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths of more than 6 feet. Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given soil mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning in soil science that may not be familiar to engineers. The Glossary defines many terms commonly used in soil science.

Engineering soil classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (*2*) used by the Soil Conservation Service, Department of Defense, and other agencies and the AASHTO system (*1*) adopted by the American Association of State Highway and Transportation Officials.

In the Unified system soils are classified according to particle-size distribution, plasticity, liquid limit, and organic matter. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, CL–ML.

The AASHTO system is used to classify soils according to those properties that affect use in highway construction and maintenance. In this system a soil is assigned to one of seven basic groups that range from A–1 to A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A–1, A–2, and A–7 groups are divided as follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7; and A–7–5 and A–7–6. As additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHTO classification for tested soils, with group index numbers in parentheses, is shown in table 6; the estimated classification, without group index numbers, is shown in table 4 for all soils mapped in the county.

Soil properties significant to engineering

Several estimated soil properties significant to engineering are shown in table 4. These estimates are made for typical soil profiles, by layers sufficiently different to have different significance for soil engineering. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties. Following are explanations of some of the columns in table 4.

Depth to bedrock is the distance from the surface of the soil to the upper surface of the rock layer.

Depth to seasonal high water table is the distance from the surface of the soil to the highest level that ground water reaches in the soil in most years.

Soil texture is described in table 4 in the standard terms used by the Department of Agriculture. These terms take into account the relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary of this soil survey.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material changes from the semisolid to the plastic state; and the liquid limit, from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic, Liquid limit and plasticity index are estimated in table 4.

TABLE 4.—*Estimated soil properties*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two kinds of soil that may have different
the first column of this table. The symbol >

Soil series and mapping units	Depth to—		Depth from surface	USDA texture	Classification	
	Bedrock	Seasonal high water table			Unified	AASHTO
	Inches	*Feet*	*Inches*			
Albion Mapped only with Shellabarger soils.	>60	>6	0–37	Fine sandy loam, sandy loam.	SM, SM–SC, SC	A–4
			37–72	Gravelly sandy loam, loamy sand, gravelly loamy sand.	SM, SP–SM, GM	A–1, A–3, A–2
Bethany: BeA	>60	>6	0–14	Silt loam	ML, CL, CL–ML	A–4, A–6
			14–18	Silty clay loam	CL	A–6, A–7
			18–80	Silty clay, silty clay loam	CL, CH	A–7
Binger: BnC	26–38	>6	0–10	Fine sandy loam	SM, SM–SC	A–2, A–4
			10–32	Sandy clay loam, fine sandy loam.	SC, CL	A–4
			32–40	Sandstone.		
*Brewer: Br, Bu For Drummond part of Bu, see Drummond series.	>60	>6	0–12	Silty clay loam, silt loam	CL, ML	A–4, A–6
			12–64	Silty clay, silty clay loam	CL, CH	A–6, A–7
			64–84	Silty clay loam, silt loam	CL, ML	A–6, A–7
Canadian: Ca	>60	>6	0–60	Fine sandy loam	SM, SC, SM–SC, ML, CL, CL–ML	A–4
Dale: Da	>60	>6	0–42	Silt loam	CL, ML, CL–ML	A–4, A–6
			42–64	Silty clay loam, silt loam.	CL, ML, CL–ML	A–4, A–6
*Darnell: DnD, DnF For Noble part, see Noble series.	10–20	>6	0–11	Fine sandy loam	ML, CL, CL–ML, SM, SC, SM–SC	A–4
			11–15	Sandstone.		
*Dill: DuD For Quinlan part, see Quinlan series.	20–40	>6	0–34	Fine sandy loam	ML, CL, CL–ML, SM, SC, SM–SC	A–4
			34	Sandstone.		
Drummond [2] Mapped only with Brewer soils.	>60	4–10	0–10	Silt loam, loam	ML, CL, CL–ML	A–4, A–6
			10–30	Silty clay loam	CL	A–6, A–7
			30–42	Clay loam, loam, silty clay loam.	CL, ML	A–6, A–7
			42–60	Clay loam	CL	A–6, A–7
Gracemore: Ga, Gb	>60	½–3	0–12	Loamy fine sand, fine sand, fine sandy loam.	SM, SM–SC, SP–SM	A–2, A–4, A–3
			0–12	Clay loam	CL	A–6
			12–72	Loamy fine sand, fine sand.	SM, SP–SM	A–2, A–3
Grandfield: GdB, GdC, GdC2, GdD, GdD3	>60	>6	0–7	Fine sandy loam, loamy fine sand.	ML, CL, CL–ML, SM, SC, SM–SC	A–4, A–2
			7–38	Sandy clay loam	SC, CL	A–4, A–6
			38–60	Fine sandy loam	SC, CL	A–4

See footnotes at end of table.

significant to engineering

properties and limitations. For this reason, it is necessary to follow carefully the instructions for referring to other series that appear in means more than; the symbol < means less than]

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Risk of corrosion to—	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*			
100	95–100	80–100	36–50	<26	[1] NP–8	2.0–6.0	0.09–0.15	6.1–7.8	Low	Low	Low.
50–100	40–100	25–80	5–35	<20	NP–4	6.0–20.0	0.03–0.10	6.6–8.4	Low	Low	Low.
	100	96–100	80–97	<37	NP–13	0.6–2.0	0.16–0.24	6.1–6.5	Low	Low	Low.
	100	98–100	90–98	37–50	15–25	0.2–0.6	0.18–0.22	6.6–7.3	Moderate	Moderate	Low.
100	95–100	98–100	90–98	45–65	22–40	0.06–0.2	0.14–0.20	6.6–8.4	High	High	Low.
100	98–100	94–100	30–50	<26	NP–6	2.0–6.0	0.10–0.14	6.6–7.3	Low	Low	Low.
90–100	83–100	75–100	36–65	25–30	7–11	0.6–2.0	0.12–0.17	6.6–7.3	Low	Moderate	Low.
	100	98–100	90–98	30–40	8–17	0.2–0.6	0.16–0.24	6.1–7.3	Moderate	Low	Low.
100	95–100	90–100	90–98	36–65	16–38	0.06–0.2	0.14–0.20	6.1–8.4	High	High	Low.
100	95–100	90–100	90–98	33–42	12–19	0.06–0.6	0.18–0.22	7.4–8.4	Moderate	Low	Low.
100	95–100	94–100	36–60	<26	NP–10	2.0–6.0	0.11–0.15	6.6–8.4	Low	Low	Low.
	100	96–100	73–95	<37	NP–13	0.6–2.0	0.16–0.24	6.1–8.4	Low	Low	Low.
100	96–100	90–99	73–98	25–40	4–17	0.6–2.0	0.16–0.24	7.9–8.4	Moderate	Moderate	Low.
100	98–100	94–100	36–60	<30	NP–10	2.0–6.0	0.11–0.15	6.1–6.5	Low	Low	Moderate.
100	98–100	94–100	36–60	<30	NP–10	2.0–6.0	0.11–0.15	6.6–7.8	Low	Low	Low.
	100	96–100	70–95	22–37	3–14	0.6–2.0	0.11–0.18	7.4–8.4	Low	High	Low.
	100	98–100	90–98	37–49	15–25	<0.06	0.09–0.17	7.4–8.4	Moderate	High	High.
	100	96–100	65–98	33–43	11–20	0.06–0.20	0.09–0.17	7.9–8.4	Moderate	High	High.
	100	96–100	80–90	34–43	13–20	0.06–0.20	0.09–0.17	7.9–8.4	Moderate	High	High.
100	98–100	82–95	5–45	<26	NP–7	2.0–6.0	0.05–0.13	7.9–8.4	Low	Low	Low.
	100	96–100	80–90	34–40	13–18	0.2–0.6	0.15–0.20	7.9–8.4	Moderate	Moderate	Low.
100	98–100	82–95	5–35		NP	2.0–6.0	0.05–0.11	7.9–8.4	Low	Low	Low.
100	98–100	94–100	15–60	<30	NP–10	2.0–6.0	0.07–0.15	6.1–6.5	Low	Low	Low.
	100	90–100	40–60	25–35	8–15	0.6–2.0	0.12–0.17	6.1–7.3	Low	Moderate	Low.
95–100	95–100	85–95	40–60	<30	NP–10	2.0–6.0	0.11–0.15	6.6–7.3	Low	Low	Low.

TABLE 4.—*Estimated soil properties*

Soil series and mapping units	Depth to—		Depth from surface	USDA texture	Classification	
	Bedrock	Seasonal high water table			Unified	AASHTO
	Inches	*Feet*	*Inches*			
*Grant: GhB, GpE, GuD, GuD2 For Hinkle part of GhB, see Hinkle series; for Port part of GpE, see Pw in Port series; for Quinlan part of GuD and GuD2, see Quinlan series.	40–60	>6	0–10	Silt loam	ML, CL, CL–ML	A–4
			10–46	Silty clay loam, silt loam	CL, ML	A–4, A–6
			46–60	Silt loam, very fine sandy loam.	CL, ML, CL–ML	A–4, A–6
			60	Sandstone.		
Hinkle Mapped only with Grant and Kirkland soils.	>60	>6	0–8	Silt loam	CL, ML	A–4, A–6
			8–62	Silty clay loam, silty clay, clay loam, clay.	CH, CL	A–7
Kingfisher: KfB, KfC	26–40	>6	0–10	Silt loam	CL, ML, CL–ML	A–4
			10–28	Silt loam, silty clay loam.	CL, ML	A–4, A–6
			28–38	Silty clay loam	CL	A–6, A–7
			38	Sandstone and shale.		
*Kirkland: KrA, KrB, KsB For Hinkle part of KsB, see Hinkle series.	>60	>6	0–10	Silt loam	CL, ML	A–4, A–6
			10–80	Clay	CL, CH	A–7
Konawa: KwD	>60	>6	0–16	Loamy fine sand	SM	A–2
			16–36	Sandy clay loam	SC, CL	A–4, A–6
			36–70	Fine sandy loam, loamy fine sand.	SM, SC, SM–SC	A–2, A–4
McLain: Mc	>60	>6	0–14	Silty clay loam	CL	A–6
			14–64	Silty clay loam	CL, CH	A–6, A–7
Minco: MnD, MnF, MsB, MsC	>60	>6	0–72	Silt loam, loam, very fine sandy loam.	ML, CL, CL–ML	A–4
*Nash: NaD, NaD2, NaD3 For Quinlan part, see Quinlan series.	20–40	>6	0–33	Loam, silt loam	ML, CL, CL–ML	A–4
			33	Sandstone.		
Noble: NbC	>60	>6	0–72	Fine sandy loam	ML, CL, CL–ML, SM, SC, SM–SC	A–4
Norge: NrB, NrC, NrD	>60	>6	0–10	Silt loam	ML, CL, CL–ML	A–4
			10–15	Silt loam, silty clay loam.	CL, ML	A–4, A–6
			15–70	Silty clay loam	CL	A–6, A–7
Pond Creek: PkA, PkB	>60	>6	0–14	Silt loam	ML, CL, CL–ML	A–4
			14–19	Loam, silt loam, silty clay loam.	CL, ML	A–4, A–6
			19–66	Silty clay loam, clay loam.	CL	A–6, A–7
Port:						
Po	>60	>6	0–30	Silt loam	CL, ML	A–4, A–6
			30–70	Silt loam, silty clay loam	CL, ML	A–4, A–6
Pw	>60	>6	0–66	Silt loam, silty clay loam	ML, CL	A–4, A–6
*Quinlan: QdE, QrF For Dill part of QdE, see Dill series. No estimates for Rock outcrop part of QrF.	10–20	>6	0–12	Loam, fine sandy loam, very fine sandy loam.	ML, CL, CL–ML	A–4
			12	Sandstone.		

See footnotes at end of table.

significant to engineering—Continued

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Risk of corrosion to—	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*			
	100	96–100	80–97	22–31	2–8	0. 6–2. 0	0. 16–0. 24	6. 1–7. 3	Low	Low	Low.
	100	96–100	80–98	30–40	8–17	0. 6–2. 0	0. 16–0. 24	6. 1–8. 4	Moderate	Moderate	Low.
100	98–100	94–100	55–90	20–30	1–10	0. 6–2. 0	0. 15–0. 20	7. 4–8. 4	Low	Low	Low.
	100	96–100	80–97	30–37	8–13	0. 6–2. 0	0. 16–0. 24	6. 1–7. 3	Low	High	High.
	100	96–100	85–99	41–65	18–37	<0. 06	0. 09–0. 17	7. 4–8. 4	High	High	High.
	100	96–100	80–97	20–31	1–10	0. 6–2. 0	0. 16–0. 24	6. 1–6. 5	Low	Low	Moderate.
	100	96–100	80–98	30–40	8–17	0. 2–0. 6	0. 16–0. 24	6. 1–7. 8	Moderate	Moderate	Low.
	100	98–100	90–98	33–42	12–19	0. 2–0. 6	0. 18–0. 22	6. 6–8. 4	Moderate	Moderate	Low.
	100	96–100	80–97	30–37	8–13	0. 6–2. 0	0. 16–0. 24	6. 1–7. 3	Low	Low	Low.
	100	96–100	90–99	41–65	18–38	<0. 06	0. 12–0. 18	6. 6–8. 4	High	High	Low.
100	98–100	90–100	15–35		NP	6. 0–20. 0	0. 07–0. 11	5. 6–6. 5	Low	Low	Moderate.
	100	90–100	36–65	25–37	8–16	0. 6–2. 0	0. 12–0. 17	5. 6–6. 0	Low	Moderate	Moderate.
100	98–100	90–100	15–50	<26	NP–8	2. 0–6. 0	0. 07–0. 13	5. 6–6. 5	Low	Low	Moderate.
	100	98–100	90–98	33–40	12–17	0. 2–0. 6	0. 18–0. 22	6. 6–7. 8	Moderate	High	Low.
	100	98–100	90–98	37–60	15–35	0. 06–0. 2	0. 14–0. 22	7. 4–8. 4	High	High	Low.
	100	94–100	51–97	<31	NP–10	0. 6–2. 0	0. 13–0. 24	6. 1–8. 4	Low	Low	Low.
	100	96–100	75–90	22–31	2–10	0. 6–2. 0	0. 15–0. 24	6. 1–7. 8	Low	Low	Low.
100	98–100	94–100	36–60	<30	NP–10	2. 0–6. 0	0. 11–0. 15	6. 1–7. 3	Low	Low	Low.
	100	96–100	80–97	<31	NP–8	0. 6–2. 0	0. 16–0. 24	6. 1–6. 5	Low	Moderate	Low.
	100	96–100	80–98	30–40	8–15	0. 6–2. 0	0. 16–0. 22	6. 1–6. 5	Low	Moderate	Low.
	100	98–100	90–97	33–42	12–19	0. 2–0. 6	0. 18–0. 22	6. 6–7. 8	Moderate	Moderate	Low.
	100	96–100	80–97	18–26	2–8	0. 6–2. 0	0. 15–0. 24	5. 6–6. 5	Low	Low	Low.
	100	96–100	65–98	30–40	8–19	0. 2–0. 6	0. 15–0. 24	6. 1–7. 3	Moderate	Moderate	Low.
	100	98–100	80–98	33–42	12–19	0. 2–0. 6	0. 18–0. 22	6. 6–8. 4	Moderate	Moderate	Low.
	100	96–100	80–97	30–37	8–13	0. 6–2. 0	0. 16–0. 24	6. 6–7. 8	Low	Moderate	Low.
	100	96–100	80–98	30–40	8–18	0. 6–2. 0	0. 16–0. 24	7. 4–8. 4	Moderate	Moderate	Low.
	100	96–100	80–98	30–40	8–18	0. 6–2. 0	0. 16–0. 24	6. 6–8. 4	Moderate	Low	Low.
100	95–100	90–100	55–80	<30	NP–10	2. 0–6. 0	0. 12–0. 20	7. 9–8. 4	Low	Low	Low.

TABLE 4.—*Estimated soil properties*

Soil series and mapping units	Depth to—		Depth from surface	USDA texture	Classification	
	Bedrock	Seasonal high water table			Unified	AASHTO
	Inches	*Feet*	*Inches*			
Reinach: Ra	>60	>6	0–60	Very fine sandy loam	ML, CL, CL–ML	A–4
Renfrow:						
RbA, RbB	>60	>6	0–11	Silt loam	ML, CL, CL–ML	A–4
			11–18	Silty clay loam, clay loam.	CL	A–6, A–7
			18–65	Clay, silty clay	CL, CH	A–7
RcC2	>60	>6	0–11	Clay loam	CL, ML	A–6, A–7
			11–64	Clay, silty clay	CH, CL	A–7
Rock outcrop. Properties too variable to be estimated.						
*Shellabarger: ShB, ShC, ShD, ShD2, SnE. For Albion part of SnE, see Albion series.	>60	>6	0–12	Fine sandy loam	ML, CL, CL–ML, SM, SC, SM–SC	A–4
			12–36	Sandy clay loam, sandy loam.	SC, CL	A–4, A–6
			36–60	Sandy loam	SM, ML	A–4
Tivoli: Tv	>60	>6	0–60	Fine sand	SM, SP–SM	A–2, A–3
Vernon: VeC, VrE, VsC2	20–36	>6	0–6	Clay loam, clay	CL, CH, ML	A–6, A–7
No estimates for Rock outcrop part of VrE.			6–24	Clay	CL, CH, ML	A–7
			24–60	Clay, shale.		
Watonga: Wa	>60	>6	0–22	Silty clay	CH, CL	A–7
			22–72	Silty clay, silty clay loam	CL, CH	A–6, A–7
Yahola: Ya	>60	>6	0–40	Fine sandy loam	SM, SC, SM–SC, ML, CL, CL–ML	A–4
			40–60	Loamy fine sand, fine sandy loam.	SM, ML	A–2, A–4

[1] NP=nonplastic.

TABLE 5.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two kinds of soils that may have appear in the first column of this table. Some terms in this table

Soil series and map symbols	Suitability as source of—			Degree and kind of limitations for—		
	Road fill	Sand and gravel	Topsoil	Septic tank absorption fields	Sewage lagoons	Shallow excavations
Albion. Mapped only with Shellabarger soils.	Fair: low strength.	Unsuited in upper 37 inches: excess fines. Fair below a depth of 37 inches.	Good	Moderate: slope.	Severe: seepage.	Moderate: cutbanks cave; slope.

See footnote at end of table.

significant to engineering—Continued

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Risk of corrosion to—	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
				Percent		*Inches per hour*	*Inches per inch of soil*	*pH*			
100	98–100	94–100	55–75	<30	NP–9	0. 6–2. 0	0. 13–0. 20	6. 6–8. 4	Low	Low	Low.
	100	96–100	80–97	22–31	2–8	0. 6–2. 0	0. 16–0. 24	6. 1–6. 5	Low	Low	Low.
	100	96–100	80–98	33–43	12–20	0. 2–0. 6	0. 15–0. 22	6. 1–7. 3	Moderate	Moderate	Low.
	100	96–100	90–98	41–60	18–34	<0. 06	0. 12–0. 18	6. 6–8. 4	High	High	Low.
	100	96–100	80–90	31–42	11–18	0. 2–0. 6	0. 15–0. 20	6. 1–7. 3	Moderate	Moderate	Low.
	100	96–100	90–98	41–60	18–34	<0. 06	0. 12–0. 18	6. 6–8. 4	High	High	Low.
100	95–100	90–100	36–60	<30	NP–10	0. 6–2. 0	0. 11–0. 15	6. 1–6. 5	Low	Low	Low.
100	95–100	90–100	45–80	25–35	8–13	0. 6–2. 0	0. 12–0. 17	6. 1–7. 8	Low	Low	Low.
100	95–100	90–100	36–60	<25	NP–4	0. 6–2. 0	0. 10–0. 14	6. 6–8. 4	Low	Low	Low.
100	98–100	82–98	5–25		NP	6. 0–20. 0	0. 05–0. 08	6. 1–8. 4	Low	Low	Low.
	100	96–100	80–95	34–55	13–30	0. 2–0. 6	0. 15–0. 20	7. 9–8. 4	High	High	Low.
	100	96–100	90–95	45–70	19–38	<0. 06	0. 12–0. 18	7. 9–8. 4	High	High	Low.
	100	98–100	93–99	41–60	18–35	<0. 06	0. 14–0. 18	7. 4–8. 4	High	High	Low.
	100	98–100	90–99	37–60	15–35	0. 06–0. 2	0. 14–0. 22	7. 4–8. 4	High	High	Low.
100	98–100	94–100	36–60	<30	NP–10	2. 0–6. 0	0. 11–0. 15	7. 9–8. 4	Low	Low	Low.
100	98–100	90–100	20–60	<26	NP–4	2. 0–6. 0	0. 07–0. 15	7. 9–8. 4	Low	Low	Low.

[2] Between depths of 30 and 60 inches, the salinity rating is 2 to 4 millimhos per centimeter.

interpretations

different properties and limitations. For this reason, it is necessary to follow carefully the instructions for referring to other series that are explained in the Glossary, where they are identified by an asterisk]

Degree and kind of limitations for—Continued					Soil features affecting—		
Dwellings without basements	Sanitary landfill [1]	Local roads and streets	Pond reservoir areas	Pond embankments	Drainage of crops and pasture	Irrigation	Terraces and diversions
Slight	Severe: seepage.	Slight	Severe: seepage.	Moderate: unstable fill; piping; seepage.	Well drained	Fast intake	Erodes easily.

TABLE 5.—*Engineering*

Soil series and map symbols	Suitability as source of—			Degree and kind of limitations for—		
	Road fill	Sand and gravel	Topsoil	Septic tank absorption fields	Sewage lagoons	Shallow excavations
Bethany: BeA	Poor: shrink-swell; low strength.	Unsuited: excess fines.	Fair: thin layer.	Severe: percs slowly.	Slight	Severe: too clayey.
Binger: BnC	Fair: low strength.	Unsuited: excess fines.	Fair: thin layer.	Severe: depth to rock.	Severe: depth to rock.	Moderate: depth to rock.
*Brewer: Br, Bu For Drummond part of Bu, see Drummond series.	Poor: shrink-swell; low strength.	Unsuited: excess fines.	Fair: too clayey.	Severe: percs slowly.	Slight	Severe: too clayey.
Canadian: Ca	Fair: low strength.	Unsuited: excess fines.	Good	Moderate: floods.	Severe: seepage.	Moderate: floods.
Dale: Da	Fair: low strength; shrink-swell.	Unsuited: excess fines.	Good	Moderate: floods.	Moderate: seepage.	Moderate: floods.
*Darnell:						
DnD For Noble part, see NbC in Noble series.	Fair: thin layer; low strength.	Unsuited: excess fines.	Fair: thin layer.	Severe: depth to rock.	Severe: depth to rock; seepage.	Moderate: depth to rock.
DnF For Noble part, see Noble series.	Fair: thin layer; low strength.	Unsuited: excess fines.	Poor: slope	Severe: slope; depth to rock.	Severe: depth to rock; seepage; slope.	Severe: depth to rock; slope.
*Dill:						
DuD For Quinlan part, see QdE in Quinlan series.	Fair: thin layer; low strength.	Unsuited: excess fines.	Good	Severe: depth to rock.	Severe: seepage; depth to rock.	Moderate: depth to rock.
Dill part of QdE	Fair: thin layer; low strength.	Unsuited: excess fines.	Fair: slope	Severe: depth to rock.	Severe: seepage; depth to rock.	Moderate: depth to rock.
Drummond Mapped only with Brewer soils.	Poor: low strength; shrink-swell.	Unsuited: excess fines.	Fair: thin layer.	Severe: percs slowly; wet.	Slight	Severe: too clayey.
Gracemore: Ga	Fair: low strength; wet.	Poor for sand: excess fines. Unsuited for gravel: excess fines.	Poor: too sandy.	Severe: floods; wet.	Severe: wet; seepage; floods.	Severe: wet; floods; cutbanks cave.

See footnote at end of table.

interpretations—Continued

Degree and kind of limitations for—Continued					Soil features affecting—		
Dwellings without basements	Sanitary landfill	Local roads and streets	Pond reservoir areas	Pond embankments	Drainage of crops and pasture	Irrigation	Terraces and diversions
Severe: shrink-swell; low strength.	Severe: too clayey.	Severe: shrink-swell; low strength.	Slight	Moderate: shrink-swell; compressible; low strength.	Percs slowly	Slow intake	Percs slowly.
Slight	Moderate: depth to rock.	Moderate: low strength.	Severe: depth to rock.	Moderate: unstable fill; thin layer; piping.	Well drained	Erodes easily; rooting depth.	Erodes easily; rooting depth.
Severe: shrink-swell; floods; low strength.	Severe: too clayey.	Severe: shrink-swell; low strength.	Slight	Moderate: compressible; shrink-swell; low strength.	Percs slowly; floods.	Slow intake; floods.	Percs slowly.
Severe: floods	Severe: seepage.	Moderate: low strength.	Severe: seepage.	Moderate: piping; unstable fill; seepage.	Well drained; floods.	Fast intake; floods.	Erodes easily.
Severe: floods	Moderate: floods.	Moderate: low strength; floods; shrink-swell.	Moderate	Moderate: unstable fill; piping; low strength.	Well drained; floods.	Floods	Piping; erodes easily.
Moderate: depth to rock.	Severe: seepage.	Moderate: depth to rock; low strength.	Severe: depth to rock; seepage.	Severe: thin layer.	Somewhat excessively drained.	Rooting depth; erodes easily; slope.	Rooting depth; slope.
Severe: slope	Severe: seepage; slope.	Severe: slope.	Severe: depth to rock; seepage.	Severe: thin layer.	Somewhat excessively drained.	Rooting depth; slope; erodes easily.	Slope; rooting depth.
Slight	Severe: seepage.	Slight	Severe: seepage; depth to rock.	Moderate: thin layer; unstable fill; piping.	Well drained	Fast intake; rooting depth.	Rooting depth; erodes easily.
Moderate: slope.	Severe: seepage.	Moderate: slope.	Severe: seepage; depth to rock.	Moderate: thin layer; unstable fill; piping.	Well drained	Fast intake; rooting depth.	Rooting depth; erodes easily; slope.
Severe: shrink-swell; floods; low strength.	Severe: too clayey.	Severe: low strength; shrink-swell.	Slight	Severe: low strength; compressible; unstable fill.	Cutbanks cave; excess alkali; floods.	Excess alkali; slow intake.	Percs slowly; excess alkali.
Severe: wet; floods.	Severe: floods; wet; seepage.	Moderate: floods.	Severe: seepage.	Moderate: unstable fill; low strength.	Wet; floods; cutbanks cave.	Wet; floods	Wet.

TABLE 5.—*Engineering*

Soil series and map symbols	Suitability as source of—			Degree and kind of limitations for—		
	Road fill	Sand and gravel	Topsoil	Septic tank absorption fields	Sewage lagoons	Shallow excavations
Gracemore—Continued Gb	Fair: low strength; wet.	Poor for sand: excess fines. Unsuited for gravel: excess fines.	Poor: too sandy.	Severe: floods; wet.	Severe: wet; seepage; floods.	Severe: wet; floods; cutbanks cave.
Grandfield: Gd B, GdC, GdC2, GdD	Fair: low strength.	Unsuited: excess fines.	Fair: thin layer.	Slight	Moderate: seepage.	Slight
GdD3	Fair: low strength.	Unsuited: excess fines.	Poor: too sandy.	Slight	Moderate: seepage.	Slight
*Grant: GhB, GpE, GuD, GuD2. For Hinkle part of GhB, see Hinkle series. For Port part of GpE, see Pw in Port series. For Quinlan part of GuD and GuD2, see QdE in Quinlan series.	Poor: low strength.	Unsuited: excess fines.	Fair: thin layer.	Moderate: depth to rock; percs slowly.	Moderate: depth to rock; seepage.	Moderate: too clayey.
Hinkle Mapped only with Grant and Kirkland soils.	Poor: shrink-swell; low strength.	Unsuited: excess fines.	Poor: thin layer.	Severe: percs slowly.	Slight	Severe: too clayey.
Kingfisher: KfB, KfC	Poor: low strength.	Unsuited: excess fines.	Fair: thin layer.	Severe: depth to rock; percs slowly.	Severe: depth to rock.	Moderate: depth to rock; too clayey.
*Kirkland: KrA, KrB, KsB. For Hinkle part of KsB, see Hinkle series.	Poor: low strength; shrink-swell.	Unsuited: excess fines.	Fair: thin layer.	Severe: percs slowly.	Slight	Severe: too clayey.
Konawa: KwD	Fair: low strength.	Poor for sand: excess fines.	Poor: too sandy.	Slight	Severe: seepage.	Slight
McLain: Mc	Poor: shrink-swell: low strength.	Unsuited: excess fines.	Fair: too clayey.	Severe: percs slowly.	Slight	Severe: too clayey.
Minco: MnD, MsB, MsC	Fair: low strength.	Unsuited: excess fines.	Good	Slight	Moderate: seepage; slope.	Slight
MnF	Fair: low strength; slope.	Unsuited: excess fines.	Poor: slope.	Severe: slope.	Severe: slope.	Severe: slope.

See footnote at end of table.

interpretations—Continued

Degree and kind of limitations for—Continued					Soil features affecting—		
Dwellings without basements	Sanitary landfill [1]	Local roads and streets	Pond reservoir areas	Pond embankments	Drainage of crops and pasture	Irrigation	Terraces and diversions
Severe: wet; floods.	Severe: floods; wet; seepage.	Severe: floods.	Severe: seepage.	Moderate: unstable fill; low strength.	Wet; floods; cutbanks cave.	Wet; floods	Wet.
Slight	Slight	Moderate: low strength.	Moderate: seepage.	Moderate: unstable fill; piping; compressible.	Well drained	Erodes easily.	Erodes easily.
Slight	Slight	Moderate: low strength.	Moderate: seepage.	Moderate: unstable fill; piping; compressible.	Well drained	Erodes easily.	Erodes easily.
Moderate: low strength; shrink-swell.	Moderate: depth to rock; too clayey.	Severe: low strength.	Moderate: seepage.	Moderate: unstable fill; piping; low strength.	Well drained	Erodes easily	Erodes easily; piping.
Severe: shrink-swell; low strength.	Severe: too clayey.	Severe: shrink-swell; low strength.	Slight	Severe: unstable fill; low strength; shrink-swell.	Percs slowly; excess alkali; cutbanks cave.	Slow intake; excess alkali.	Percs slowly; excess alkali.
Moderate: shrink-swell; low strength.	Moderate: depth to rock; too clayey.	Severe: low strength.	Moderate: seepage.	Moderate: thin layer; piping; unstable fill.	Well drained	Erodes easily	Rooting depth; erodes easily; piping.
Severe: low strength; shrink-swell.	Severe: too clayey.	Severe: low strength; shrink-swell.	Slight	Moderate: compressible; shrink-swell; low strength.	Percs slowly	Slow intake	Percs slowly.
Slight	Severe: seepage.	Moderate: low strength.	Severe: seepage.	Moderate: unstable fill; low strength.	Well drained	Erodes easily	Erodes easily.
Severe: low strength; floods; shrink-swell.	Severe: too clayey.	Severe: shrink-swell; low strength.	Slight	Moderate: shrink-swell; compressible; low strength.	Percs slowly; floods.	Slow intake; floods.	Percs slowly.
Moderate: low strength.	Slight	Moderate: low strength.	Moderate: seepage.	Moderate: unstable fill; piping; seepage.	Well drained	Erodes easily	Erodes easily; piping.
Severe: slope.	Severe: slope.	Severe: slope.	Moderate: seepage.	Moderate: unstable fill; piping; seepage.	Well drained	Slope; erodes easily.	Slope; erodes easily; piping.

TABLE 5.—*Engineering*

Soil series and map symbols	Suitability as source of—			Degree and kind of limitations for—		
	Road fill	Sand and gravel	Topsoil	Septic tank absorption fields	Sewage lagoons	Shallow excavations
*Nash: NaD, NaD2, NaD3—For Quinlan part, see QdE in Quinlan series.	Fair: thin layer; low strength.	Unsuited: excess fines.	Good	Severe: depth to rock.	Severe: depth to rock.	Moderate: depth to rock.
Noble: NbC	Fair: low strength.	Unsuited: excess fines.	Good	Slight	Severe: seepage.	Slight
Noble part of DnF	Fair: low strength; slope.	Unsuited: excess fines.	Poor: slope	Severe: slope.	Severe: seepage; slope.	Severe: slope.
Norge: NrB, NrC, NrD	Poor: low strength.	Unsuited: excess fines.	Fair: thin layer.	Severe: percs slowly.	Moderate: slope.	Moderate: too clayey.
Pond Creek: PkA, PkB	Poor: low strength.	Unsuited: excess fines.	Fair: thin layer.	Severe: percs slowly.	Slight	Moderate: too clayey.
Port: Po	Fair: low strength; shrink-swell.	Unsuited: excess fines.	Good	Severe: floods.	Severe: floods.	Severe: floods.
Pw	Fair: low strength; shrink-swell.	Unsuited: excess fines.	Fair: too clayey.	Severe: floods.	Severe: floods.	Severe: floods.
*Quinlan: QdE—For Dill part, see Dill series.	Fair: low strength; thin layer.	Unsuited: excess fines.	Fair: thin layer.	Severe: depth to rock.	Severe: depth to rock.	Moderate: depth to rock.
QrF—No interpretations for Rock outcrop part.	Fair: low strength; thin layer.	Unsuited: excess fines.	Fair: thin layer.	Severe: slope; depth to rock.	Severe: slope; depth to rock.	Severe: slope; depth to rock.
Reinach: Ra	Fair: low strength.	Unsuited: excess fines.	Good	Moderate: floods.	Moderate: seepage.	Moderate: floods.
Renfrow: RbA, RbB	Poor: low strength; shrink-swell.	Unsuited: excess fines.	Fair: thin layer.	Severe: percs slowly.	Slight	Severe: too clayey.
RcC2	Poor: low strength; shrink-swell.	Unsuited: excess fines.	Fair: too clayey.	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.
Rock outcrop. No interpretations made.						

See footnote at end of table.

interpretations—Continued

Degree and kind of limitations for—Continued					Soil features affecting—		
Dwellings without basements	Sanitary landfill [1]	Local roads and streets	Pond reservoir areas	Pond embankments	Drainage of crops and pasture	Irrigation	Terraces and diversions
Moderate: low strength.	Moderate: depth to rock.	Moderate: low strength.	Severe: depth to rock.	Moderate: unstable fill; piping; thin layer.	Well drained	Erodes easily; rooting depth.	Rooting depth; erodes easily; piping.
Slight	Severe: seepage.	Moderate: low strength.	Severe: seepage.	Moderate: unstable fill; low strength; seepage.	Well drained	Fast intake	Erodes easily.
Severe: slope.	Severe: seepage; slope.	Severe: slope.	Severe: seepage.	Moderate: unstable fill; low strength; seepage.	Well drained	Slope; fast intake.	Slope; erodes easily.
Moderate: shrink-swell; low strength.	Moderate: too clayey.	Severe: low strength.	Moderate: seepage.	Moderate: unstable fill; piping; low strength.	Well drained	Erodes easily	Erodes easily; piping.
Moderate: shrink-swell; low strength.	Moderate: too clayey.	Severe: low strength.	Moderate: seepage.	Moderate: unstable fill; piping; low strength.	Well drained	Erodes easily	Erodes easily; piping.
Severe: floods.	Severe: floods.	Moderate: low strength; shrink-swell; floods.	Moderate: seepage.	Moderate: unstable fill; piping; low strength.	Well drained; floods.	Floods	Piping; erodes easily.
Severe: floods.	Severe: floods.	Severe: floods.	Moderate: seepage.	Moderate: unstable fill; piping; low strength.	Well drained; floods.	Floods	Piping; erodes easily.
Moderate: depth to rock.	Moderate: depth to rock.	Moderate: low strength; depth to rock.	Severe: depth to rock; seepage.	Severe: thin layer.	Well drained	Erodes easily; rooting depth; slope.	Rooting depth; slope.
Severe: slope.	Moderate: depth to rock.	Severe: slope.	Severe: depth to rock; seepage.	Severe: thin layer.	Well drained	Slope; erodes easily; rooting depth.	Slope; rooting depth.
Severe: floods	Moderate: floods.	Moderate: low strength; floods.	Moderate: seepage.	Moderate: unstable fill; piping.	Well drained	Floods	Piping; erodes easily.
Severe: low strength; shrink-swell.	Severe: too clayey.	Severe: low strength; shrink-swell.	Slight	Moderate: compressible; shrink-swell; low strength.	Percs slowly	Slow intake; erodes easily.	Percs slowly; erodes easily.
Severe: low strength; shrink-swell.	Severe: too clayey.	Severe: low strength; shrink-swell.	Slight	Moderate: compressible; shrink-swell; low strength.	Percs slowly	Slow intake; erodes easily.	Percs slowly; erodes easily.

TABLE 5.—*Engineering*

Soil series and map symbols	Suitability as source of—			Degree and kind of limitations for—		
	Road fill	Sand and gravel	Topsoil	Septic tank absorption fields	Sewage lagoons	Shallow excavations
*Shellabarger: ShB, ShC, ShD, ShD2	Fair: low strength.	Unsuited: excess fines.	Fair: thin layer.	Slight	Moderate: seepage.	Slight
SnE For Albion part, see Albion series.	Fair: low strength.	Unsuited: excess fines.	Fair: slope; thin layer.	Moderate: slope.	Severe: slope.	Moderate: slope.
Tivoli: Tv	Good	Unsuited: excess fines.	Poor: too sandy.	Moderate: slope.	Severe: seepage.	Severe: too sandy; cutbanks cave.
Vernon: VeC, VsC2	Poor: shrink-swell; low strength.	Unsuited: excess fines.	Poor: too clayey.	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.
VrE No interpretations for Rock outcrop part.	Poor: shrink-swell; low strength.	Unsuited: excess fines.	Poor: too clayey.	Severe: percs slowly.	Severe: slope.	Severe: too clayey.
Watonga: Wa	Poor: shrink-swell; low strength.	Unsuited: excess fines.	Poor: too clayey.	Severe: percs slowly.	Slight	Severe: too clayey.
Yahola: Ya	Fair: low strength.	Unsuited: excess fines.	Good	Severe: floods.	Severe: seepage; floods.	Severe: floods.

[1] Onsite study is needed of the underlying strata and water table to determine the hazards of aquifer pollution and drainage into

but in table 6 the data on liquid limit and plasticity index are based on tests of soil samples.

Permeability is the quality that enables a soil to transmit water or air. It is estimated on the basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in table 4 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants.

Reaction is the degree of acidity or alkalinity of a soil, expressed as a pH value. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is the relative change in volume to be expected of soil material with changes in moisture content, that is, the extent to which the soil shrinks as it dries out and swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils causes much damage to building foundations, roads, and other structures. A *high* shrink-swell potential indicates a hazard to maintenance of structures built in, on, or with material that has this rating.

Risk of corrosion, as used in table 4, pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. Rate of corrosion of uncoated steel is related to such soil properties as drainage, texture, total acidity, and electrical conductivity of the soil material. Corrosivity for concrete is influenced mainly by the content of sodium or magnesium sulfate, but also by soil texture and acidity. Installations of uncoated steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations made entirely in one kind of soil or in one soil horizon. A rating of *low* indicates a low probability of soil-induced corrosion

interpretations—Continued

Degree and kind of limitations for—Continued					Soil features affecting—		
Dwellings without basements	Sanitary landfill [1]	Local roads and streets	Pond reservoir areas	Pond embankments	Drainage of crops and pasture	Irrigation	Terraces and diversions
Slight	Slight	Moderate: low strength.	Moderate: seepage.	Moderate: unstable fill; piping; low strength.	Well drained	Erodes easily	Erodes easily.
Moderate: slope.	Moderate: slope.	Moderate: slope; low strength.	Moderate: seepage.	Moderate: unstable fill; piping; low strength.	Well drained	Erodes easily; slope.	Erodes easily; slope.
Moderate: slope.	Severe: seepage; too sandy.	Moderate: slope.	Severe: seepage.	Severe: unstable fill; seepage.	Excessively drained.	Too sandy; slope.	Erodes easily; slope.
Severe: shrink-swell; low strength.	Severe: too clayey.	Severe: shrink-swell; low strength.	Slight	Moderate: compressible; shrink-swell; low strength.	Percs slowly	Slow intake; rooting depth.	Percs slowly; erodes easily.
Severe: shrink-swell; low strength.	Severe: too clayey.	Severe: shrink-swell; low strength.	Slight	Moderate: compressible; shrink-swell; low strength.	Percs slowly	Slope; slow intake; rooting depth.	Percs slowly; slope; erodes easily.
Severe: shrink-swell; floods; low strength.	Severe: too clayey.	Severe: shrink-swell; low strength.	Slight	Moderate: compressible; shrink-swell; low strength.	Percs slowly; floods.	Slow intake; floods.	Percs slowly.
Severe: floods	Severe: seepage; floods.	Moderate: floods; low strength.	Severe: seepage.	Moderate: seepage; unstable fill; piping.	Well drained; floods.	Fast intake; floods.	Erodes easily.

[1] ground water in landfill deeper than 5 or 6 feet.

damage. A rating of *high* indicates a high probability of damage, so that protective measures for steel and more resistant concrete should be used to avoid or minimize damage.

Engineering interpretations

The estimated interpretations in table 5 are based on the engineering properties of soils shown in table 4, on test data for soils in this survey area and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of Canadian County. In table 5, ratings are used to summarize limitation or suitability of the soils for all listed purposes other than for drainage of crops and pasture, irrigation, and terraces and diversions. For these particular uses, table 4 lists those soil features significant in engineering not to be overlooked in planning, installation, and maintenance.

Soil limitations are expressed as slight, moderate, severe, and very severe. *Slight* indicates soil properties generally favorable for the rated use, or in other words, limitations that are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* indicates soil properties so unfavorable and so difficult to correct or overcome that major soil reclamation, special design, or intensive maintenance is required. *Very severe* indicates one or more soil properties so unfavorable for a particular use that overcoming the limitation is most difficult and costly and commonly is not practical for the rated use.

Soil suitability is expressed as *good, fair,* and *poor,* which have, respectively, meanings approximately parallel to the terms slight, moderate, and severe.

Following are explanations of some of the columns in table 5.

TABLE 6.—*Engineering*

[Tests performed by the State of Oklahoma

Soil name and location	Parent material	Depth	Shrinkage limit	Shrinkage ratio	Volume change from field moisture equivalent
		Inches	*Percent*		*Percent*
Bethany silt loam:					
2,000 feet south of the northwest corner sec. 13, T. 11 N., R. 8 W. (Modal).	Loamy and clayey sediments.	0–8	[3] NP	NP	NP
		18–34	11	1. 93	54
		34–60	9	2. 05	73
Dale silt loam:					
1,460 feet south and 2,300 feet east of the northwest corner sec. 28, T. 13 N., R. 8 W. (Modal).	Loamy sediments.	0–7	NP	NP	NP
		24–42	NP	NP	NP
Minco silt loam:					
800 feet south and 600 feet west of the northeast corner sec. 13, T. 11 N., R. 10 W. (Modal).	Loamy sediments.	0–12	17	1. 72	12
		12–28	16	1. 76	13
		28–48	14	1. 82	14
Norge silt loam:					
650 feet west and 300 feet north of the southeast corner sec. 3, T. 12 N., R. 8 W. (Modal).	Loamy sediments.	0–10	NP	NP	NP
		16–30	13	1. 84	31
		30–44	12	1. 91	33
Pond Creek silt loam:					
1,000 feet east of the northwest corner sec. 7, T. 13 N., R. 9 W. (Modal).	Loamy sediments.	0–12	NP	NP	NP
		18–26	11	1. 94	58
		40–60	16	1. 77	22
Reinach very fine sandy loam:					
2,000 feet north of the southwest corner sec. 34, T. 11 N., R. 8 W. (Modal).	Loamy sediments.	0–14	NP	NP	NP
		14–26	NP	NP	NP
		36–52	NP	NP	NP
Renfrow clay loam:					
4,000 feet south and 1,500 feet west of the northeast corner sec. 25, T. 14 N., R. 5 W. (Modal).	Shale or clayey sediments.	0–8	12	1. 90	51
		8–24	8	2. 11	80
		36–48	9	2. 07	77
Shellabarger fine sandy loam:					
1,200 feet west and 500 feet north of southeast corner sec. 18, T. 13 N., R. 7 W. (Modal).	Loamy sediments.	0–7	NP	NP	NP
		22–40	15	1. 85	24
		52–64	14	1. 86	15

[1] Mechanical analyses according to the AASHTO Designation T 88. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHTO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method

Road fill is soil material used in embankments for roads. The suitability ratings reflect the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and, also, the relative ease of excavating the material at borrow areas.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 5 provide guidance in where to look for probable sources. A soil rated as a *good* or *fair* source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials. Neither do they indicate quality of the deposit.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as for preparing a seedbed; natural fertility of the material, or the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments are characteristics that affect suitability, but also considered in the ratings is damage that will result at the area from which topsoil is taken.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from a depth of 18 inches to 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope is a soil property that affects difficulty of layout and con-

test data

Department of Highways, Materials Division]

Mechanical analysis [1]						Liquid limit	Plasticity index	Classification	
Percentage passing sieve—			Percentage smaller than—						
No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	0.05 mm	0.005 mm	0.002 mm			AASHTO [2]	Unified
						Percent			
100	99	90	75	17	14	NP	NP	A-4(8)	ML
100	99	93	85	36	34	41	18	A-7-6(11)	CL, ML
100	98	95	88	44	37	45	22	A-7-6(14)	CL
----------	100	57	35	9	8	NP	NP	A-4(4)	ML
----------	100	79	58	13	10	NP	NP	A-4(8)	ML
100	99	73	54	15	12	25	3	A-4(8)	ML
----------	100	74	60	15	12	25	4	A-4(8)	CL-ML
100	99	73	60	20	14	25	5	A-4(8)	CL-ML
100	98	88	77	17	12	NP	NP	A-4(8)	ML
100	99	93	85	31	25	32	13	A-6(9)	CL
----------	100	94	88	34	26	31	12	A-6(9)	CL
----------	100	91	75	17	13	NP	NP	A-4(8)	ML
----------	100	93	85	37	33	41	19	A-7-6(12)	CL
----------	100	92	80	24	20	29	9	A-4(8)	CL
100	99	74	50	10	7	NP	NP	A-4(8)	ML
----------	100	73	49	10	8	NP	NP	A-4(8)	ML
----------	100	56	56	10	8	NP	NP	A-4(8)	ML
----------	100	99	95	48	40	42	16	A-7-6(11)	CL, ML
----------	100	99	96	63	55	51	22	A-7-6(15)	CH, MH
----------	100	99	97	65	55	49	20	A-7-6(14)	CL, ML
100	98	77	61	14	11	NP	NP	A-4(8)	ML
100	98	82	74	26	24	30	11	A-6(8)	CL
100	85	31	27	17	15	24	9	A-2-4(0)	SC

and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

[2] Based on AASHTO Designation M 145-49.

[3] NP=Nonplastic.

struction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor and sides, or embankments, of compacted soil material. The assumption is made that the embankment is compacted to medium density and the pond is protected from flooding. Properties are considered that affect the pond floor and the embankment. Those that affect the pond floor are permeability, organic matter, and slope. If the floor needs to be leveled, depth to bedrock is important. The soil properties that affect the embankment are the engineering properties of the embankment material as interpreted from the Unified soil classification and the amount of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Shallow excavations are those that require digging or trenching to a depth of less than 6 feet, as for example, excavations for pipelines, sewerlines, phone and power transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or big stones, and freedom from flooding or a high water table.

Dwellings without basements, as rated in table 5, are no more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load and those that relate to ease of excavation. Soil properties that affect capacity to support

load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Some soil properties that effect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the ratings in table 5 apply only to a depth of about 6 feet; therefore, limitation ratings of *slight* or *moderate* may not be valid if trenches are to be much deeper than that. For some soils, reliable predictions can be made to a depth of 10 or 15 feet, but regardless of that, every site should be investigated before it is selected.

Local roads and streets, as rated in table 5, have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base consisting of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity and stability of the subgrade and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material and, also, the shrink-swell potential indicate the traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Pond embankments require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility. Stones or organic materials in a soil are among factors that are unfavorable.

Drainage of crops and pasture is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock, or other layers that influence rate of water movement; depth to the water table; slope stability in ditchbanks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, erosion, and soil blowing; soil texture; content of stones; accumulations of salts and alkali; depth of root zone; rate of water intake at the surface; permeability of soil layers below the surface layer and in fragipans or other layers that restrict movement of water; amount of water held available for plants; and need for drainage, or depth to water table or bedrock.

Terraces and diversions are embankments, or ridges, constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope, depth to bedrock or other unfavorable material, presence of stones, permeability, and resistance to erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff and is not difficult to vegetate.

Soil test data

Table 6 shows engineering test data for some of the major soil series in Canadian County. These tests were made to help evaluate the soils for engineering purposes. The engineering classifications shown are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. The mechanical analyses were made by combined sieve and hydrometer methods.

Shrinkage limit is the percentage of moisture at which shrinkage of the soil material stops.

Shrinkage ratio is the relation of change in volume of the soil material to the water content of the soil material at the shrinkage limit. The change in volume is expressed as a percentage of the air-dry volume of the soil material, and the water content is expressed as a percentage of the weight of the soil material when ovendry.

The data on volume change indicate the amount of shrinkage and swelling that is obtained from the sample prepared at optimum moisture content and then subjected to drying and wetting. The total change that can occur in a specified soil is the sum of the value given for shrinkage and for swelling.

Tests to determine liquid limit and plastic limit measure the effect of water on the consistence of soil material, as has been explained for table 4.

Recreation

Knowledge of soils is necessary in planning, developing, and maintaining areas used for recreation. In table 7 the soils of Canadian County are rated according to limitations that affect their suitability for camp areas, picnic areas, playgrounds, and paths and trails.

In table 7 the soils are rated as having slight, moderate, or severe limitations for the specified uses. For all of these ratings, it is assumed that a good cover of vegetation can be established and maintained. A limitation of *slight* means that soil properties are generally favorable and limitations are so minor that they easily can be overcome. A *moderate* limitation is one that can be overcome or modified by planning, design, or special maintenance. A *severe* limitation means that costly soil reclamation, special design, intense maintenance, or a combination of these is required.

Camp areas are used intensively for tents and small camp trailers and the accompanying activities of outdoor living. Little preparation of the site is required other than shaping and leveling for tent and parking areas. Camp areas are subject to heavy foot traffic and limited vehicular traffic. The best soils have mild slopes, good drainage, a surface free of rocks and coarse fragments, freedom from flooding during periods of heavy use, and a surface that is firm after rain but not dusty when dry.

Picnic areas are attractive natural or landscaped tracts used mainly for preparing meals and eating outdoors. These areas are subject to heavy foot traffic. Most of the

TABLE 7.—*Recreational development*

[Ratings apply only to the named soil. For rating of other soils in a mapping unit, see the appropriate series. Some terms in this table are explained in the Glossary, where they are identified by an asterisk]

Soil series and map symbols	Degree and kind of limitation for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
Albion	Moderate: slope	Moderate: slope	Severe: slope	Slight.
Mapped only with Shellabarger soils.				
Bethany: BeA	Moderate: percs slowly.	Slight	Moderate: percs slowly.	Slight.
Binger: BnC	Slight	Slight	Moderate: slope	Slight.
Brewer: Br, Bu	Severe: floods	Moderate: too clayey; floods.	Moderate: percs slowly; floods.	Moderate: too clayey.
Canadian: Ca	Severe: floods	Moderate: floods	Moderate: floods	Slight.
Dale: Da	Severe: floods	Moderate: floods	Moderate: floods	Slight.
Darnell:				
DnD	Slight	Slight	Severe: depth to rock	Slight.
DnF	Severe: slope	Severe: slope	Severe: depth to rock	Moderate: slope.
Dill: DuD	Slight	Slight	Moderate: slope	Slight.
Drummond	Severe: percs slowly; floods.	Moderate: wet; floods.	Severe: percs slowly	Moderate: wet.
Mapped only with Brewer soils.				
Gracemore:				
Ga	Severe: floods	Moderate: wet; floods.	Moderate: wet; floods.	Moderate: wet; floods.
Gb	Severe: floods	Severe: floods	Severe: floods	Moderate: wet; floods.
Grandfield:				
GdB	Slight	Slight	Slight	Slight.
GdC, GdC2	Slight	Slight	Moderate: slope	Slight.
GdD, GdD3	Slight	Slight	Severe: slope	Slight.
Grant:				
GhB	Slight	Slight	Slight	Slight.
GpE	Moderate: slope	Moderate: slope	Severe: slope	Slight.
GuD, GuD2	Slight	Slight	Severe: slope	Slight.
Hinkle	Severe: percs slowly	Slight	Severe: percs slowly	Slight.
Mapped only with Grant and Kirkland soils.				
Kingfisher:				
KfB	Moderate: percs slowly.	Slight	Moderate: percs slowly.	Slight.
KfC	Moderate: percs slowly.	Slight	Moderate: percs slowly; slope.	Slight.
Kirkland: KrA, KrB, KsB	Severe: percs slowly	Slight	Severe: percs slowly	Slight.
Konawa: KwD	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy; slope.	Moderate: too sandy.
McLain: Mc	Moderate: floods	Moderate: floods; too clayey.	Moderate: floods; percs slowly.	Moderate: too clayey.
Minco:				
MnD	Slight	Slight	Severe: slope	Slight.
MnF	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
MsB	Slight	Slight	Slight	Slight.
MsC	Slight	Slight	Moderate: slope	Slight.
Nash: NaD, NaD2, NaD3	Slight	Slight	Severe: slope	Slight.
Noble:				
DnD	Slight	Slight	Severe: slope	Slight.
DnF	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
NbC	Slight	Slight	Moderate: slope	Slight.
Norge:				
NrB	Moderate: percs slowly.	Slight	Moderate: percs slowly.	Slight.
NrC	Moderate: percs slowly.	Slight	Moderate: percs slowly; slope.	Slight.
NrD	Moderate: percs slowly.	Slight	Moderate: slope	Slight.
Pond Creek: PkA, PkB	Moderate: percs slowly.	Slight	Moderate: percs slowly.	Slight.
Port:				
Po	Severe: floods	Moderate: floods	Moderate: floods	Slight.
Pw	Severe: floods	Severe: floods	Severe: floods	Moderate: floods.

TABLE 7.—*Recreational development*—Continued

Soil series and map symbols	Degree and kind of limitation for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
Quinlan:				
GuD, GuD2, NaD, NaD2, NaD3.	Slight	Slight	Severe: depth to rock.	Slight.
QdE	Moderate: slope	Moderate: slope	Severe: depth to rock.	Slight.
QrF	Severe: slope	Severe: slope	Severe: depth to rock.	Moderate: slope.
Rock outcrop.				
Properties too variable to be rated.				
Reinach: Ra	Severe: floods	Moderate: floods	Moderate: floods	Slight.
Renfrow:				
RbA, RbB	Severe: percs slowly	Slight	Severe: percs slowly	Slight.
RcC2	Severe: percs slowly	Moderate: too clayey.	Severe: percs slowly	Moderate: too clayey.
Shellabarger:				
ShB	Slight	Slight	Slight	Slight.
ShC	Slight	Slight	Moderate: slope	Slight.
ShD, ShD2	Slight	Slight	Severe: slope	Slight.
SnE	Moderate: slope	Moderate: slope	Severe: slope	Slight.
Tivoli: Tv	Severe: too sandy; dusty.	Severe: too sandy; dusty.	Severe: too sandy; dusty.	Severe: too sandy; dusty.
Vernon:				
VeC, VsC2	Severe: too clayey; percs slowly.	Severe: too clayey	Severe: too clayey; percs slowly.	Severe: too clayey.
VrE	Severe: too clayey; percs slowly.	Severe: too clayey	Severe: too clayey; slope; percs slowly.	Severe: too clayey.
Watonga: Wa	Severe: percs slowly; too clayey.	Severe: too clayey	Severe: too clayey; percs slowly.	Severe: too clayey.
Yahola: Ya	Severe: floods	Moderate: floods	Moderate: floods	Slight.

vehicular traffic, however, is confined to access roads. The best soils are firm when wet but not dusty when dry, are free from flooding during the season of use, and do not have strong slopes or stoniness that greatly increase the cost of leveling sites or of building access roads.

Playgrounds are areas used intensively for baseball, football, badminton, and similar organized games. Soils suitable for this use need to withstand intensive foot traffic. The best soils have a nearly level surface free of coarse fragments and rock outcrops, good drainage, freedom from flooding during periods of heavy use, and a surface that is firm after rain but not dusty when dry. If grading and leveling are required, depth to rock is important.

Paths and trails are used for local and cross-country travel by foot or on horseback. Design and layout should require little or no cutting and filling. The best soils are at least moderately well drained, are firm when wet but not dusty when dry, are flooded no more than once during the season of use, have slopes of less than 15 percent, and have few or no rocks or stones on the surface.

Formation and Classification of the Soils

This section describes the major factors of soil formation as they relate to the soils of Canadian County, the processes of soil formation, and the system of classifying soils into categories broader than the series.

Factors of Soil Formation

Soil is the product of five major factors of soil formation—parent material, climate, plants and animals (especially plants), relief, and time. If a factor, such as climate or vegetation, differs in one area from the same factor in another area, but the other four factors are the same, the soil formed in one area differs from that formed in another area.

Parent material.—Parent material is the unconsolidated material from which soil forms. It influences the rate of soil formation; the chemical, physical, and mineralogical composition; and the color of the soil.

Soils of the uplands of Canadian County formed in material weathered from sandstone and shale laid down during the Permian geologic period and from clayey, loamy, or sandy sediments. Soils of the Binger, Darnell, Dill, Nash, and Quinlan series are examples of soils that formed in material weathered from sandstone. Soils of the Canadian, Dale, Gracemore, Grandfield, Minco, Norge, Pond Creek, Port, Reinach, Shellabarger, Tivoli, and Watonga series formed in clayey, loamy, and sandy sediments. Kirkland, Renfrow, and Vernon soils formed in material weathered from shale.

Alluvial sediments are extensive along the streams and rivers of the county. The kind of sediment deposited and the kinds of soil that formed in it depend largely on the source of the sediment and the velocity of the floodwaters. Gracemore soils formed in the sandy sediments dropped near the streambed when these streams overflowed. Dale soils formed in loamy sediments dropped from slow-moving water at the outer edge of the flood plain.

Climate.—Canadian County has a warm, temperate climate. Precipitation is adequate for leaching plant

nutrients and providing plant growth. The climate is fairly uniform throughout the county, and differences among the soils cannot be attributed to differences in climate.

Plants and animals.—Plants, burrowing animals, insects, and soil micro-organisms have a direct influence on the formation of soils. The native grasses and the trees in the county have had different effects on the losses and gains of organic matter and plant nutrients and on soil structure and porosity. Soils formed under prairie vegetation, such as those of the Pond Creek series, have a thick, dark-colored surface layer and a moderately high organic-matter content. Soils formed under trees, Konawa soils, for example, have a thin surface layer and a moderate organic-matter content.

Relief.—Relief has influenced the formation of the soils mainly through its effect on the movement of water, erosion, soil temperature, and the kind of plant cover. In Canadian County relief is determined largely by the resistance of underlying formations to weathering and geologic erosion. About 24 percent of the acreage of Canadian County is nearly level soils on flood plains, and 76 percent is nearly level to steep soils on uplands.

Quinlan and Grant soils formed in similar sandstone parent material, but their formation has been controlled to a large extent by relief. The shallow Quinlan soils are more sloping than the deep Grant soils.

Time.—Time as a factor in soil formation cannot be measured strictly in years. The length of time needed for the formation of genetic horizons depends on the intensity and the interactions of soil-forming factors in promoting the losses, gains, transfers, or transformations of soil constituents that are necessary for forming soil horizons. Soils that have no definite genetic horizons are young, or immature. Mature, or older, soils have approached equilibrium with their environment and tend to have well-defined horizons.

The soils of Canadian County range from young to old. Some of the old, mature soils are Kirkland soils on uplands. Grant soils are younger, but they have well-expressed soil horizons. The Quinlan and Darnell soils are considered young soils. They have had sufficient time to form well-expressed horizons; but because they are sloping, they have had soil material removed by geologic erosion almost as fast as it forms. The Gracemore and Yahola soils are on flood plains and have been forming for such a short time that they show little formation of distinct horizons.

Processes of Soil Formation

Several processes were involved in the formation of the soils of Canadian County. These processes are the accumulation of organic matter, the leaching of calcium carbonates and bases, the reduction and transfer of iron, and the formation and translocation of silicate clay minerals. The results of these processes are not evident to the same degree in all soils of the county.

Most of the older soils in the county have three major horizons. Some of the properties in which the major horizons differ are color, texture, structure, consistence, reaction, organic-matter content, and thickness. Subdivisions of the major horizons are based on minor differences.

The A horizon is the surface layer. The A1 horizon is a division of the surface layer in which there is an accumulation of organic matter. The A2 horizon is a division that is lighter colored and leached of bases. Some of the soils of this county, such as those of the Konawa series, have both an A1 and an A2 horizon.

The B horizon is the mineral horizon below the A horizon, generally called the subsoil. In the older soils of the county, such as those of the Kirkland series, this is the horizon of maximum accumulation of silicate clay. The younger soils of the county, such as those of the Yahola series, do not have a B horizon.

The C horizon is weathered rock material. It has been affected by soil-forming processes and has been modified by reduction of iron or accumulation of calcium carbonates in some soils.

The R layer is consolidated, hard bedrock.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison of large areas, such as countries and continents.

Two systems of soil classification have been used in the United States in recent years. The older system was adopted in 1938 (*3*) and revised later (*5*). The system currently used by the National Cooperative Soil Survey was developed in the early sixties (*4*) and adopted in 1965 (*7*).

The current system of classification has six categories. Beginning with the broadest, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that soils of similar genesis, or mode of origin, are grouped. In table 8, the soil series of Canadian County are placed in six categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, which occur in many different climates. Each order is named with a word of three or four syllables ending in *sol* (Ent-i-sol).

SUBORDER. Each order is divided into suborders that are based mainly on those soil characteristics that seem to produce classes that have the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging, or soil differences that result from the climate or vegetation. The names of suborders

TABLE 8.—*Classification of the soil series in Canadian County*

[The series classification is based on their classification in November 1972]

Series	Family	Subgroup	Order
Albion	Coarse-loamy, mixed, thermic	Udic Argiustolls	Mollisols.
Bethany	Fine, mixed, thermic	Pachic Paleustolls	Mollisols.
Binger	Fine-loamy, mixed, thermic	Udic Rhodustalfs	Alfisols.
Brewer	Fine, mixed, thermic	Pachic Argiustolls	Mollisols.
Canadian	Coarse-loamy, mixed, thermic	Udic Haplustolls	Mollisols.
Dale	Fine-silty, mixed, thermic	Pachic Haplustolls	Mollisols.
Darnell	Loamy, siliceous, thermic, shallow	Udic Ustochrepts	Inceptisols.
Dill	Coarse-loamy, mixed, thermic	Udic Ustochrepts	Inceptisols.
Drummond	Fine, mixed, thermic	Mollic Natrustalfs	Alfisols.
Gracemore	Sandy, mixed, thermic	Aquic Udifluvents	Entisols.
Grandfield	Fine-loamy, mixed, thermic	Udic Haplustalfs	Alfisols.
Grant	Fine-silty, mixed, thermic	Udic Argiustolls	Mollisols.
Hinkle	Fine, montmorillonitic, thermic	Mollic Natrustalfs	Alfisols.
Kingfisher	Fine-silty, mixed, thermic	Udic Argiustolls	Mollisols.
Kirkland	Fine, mixed, thermic	Udertic Paleustolls	Mollisols.
Konawa	Fine-loamy, mixed, thermic	Ultic Haplustalfs	Alfisols.
McLain	Fine, mixed, thermic	Pachic Argiustolls	Mollisols.
Minco	Coarse-silty, mixed, thermic	Udic Haplustolls	Mollisols.
Nash	Coarse-silty, mixed, thermic	Udic Haplustolls	Mollisols.
Noble	Coarse-loamy, siliceous, thermic	Udic Ustochrepts	Inceptisols.
Norge	Fine-silty, mixed, thermic	Udic Paleustolls	Mollisols.
Pond Creek	Fine-silty, mixed, thermic	Pachic Argiustolls	Mollisols.
Port	Fine-silty, mixed, thermic	Cumulic Haplustolls	Mollisols.
Quinlan	Loamy, mixed, thermic, shallow	Typic Ustochrepts	Inceptisols.
Reinach	Coarse-silty, mixed, thermic	Pachic Haplustolls	Mollisols.
Renfrow	Fine, mixed, thermic	Udertic Paleustolls	Mollisols.
Shellabarger	Fine-loamy, mixed, thermic	Udic Argiustolls	Mollisols.
Tivoli	Mixed, thermic	Typic Ustipsamments	Entisols.
Vernon	Fine, mixed, thermic	Typic Ustochrepts	Inceptisols.
Watonga	Fine, montmorillonitic, thermic	Udic Pellusterts	Vertisols.
Yahola	Coarse-loamy, mixed (calcareous), thermic	Typic Ustifluvents	Entisols.

have two syllables. The last syllable indicates the order. An example is *Aquent* (*Aqu*, meaning water or wet; and *ent*, from Entisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus has accumulated; those that have pans that interfere with growth of roots, movement of water, or both; and thick, dark-colored surface horizons. The features used are the self-mulching properties of clay, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), dark-red and dark-brown colors associated with basic rocks, and the like. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder. An example is *Haplaquents* (*Hapl*, meaning simple horizons; *aqu*, for wetness or water; and *ent*, from Entisols).

SUBGROUP. Great groups are divided into subgroups, one that represents the central (typic) segment of the group, and others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives in front of the name of the great group. An example is *Typic Haplaquents* (a typical Haplaquent).

FAMILY. Soil families are established within a subgroup mainly on the basis of properties important to the growth of plants or on the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, and so on, that are used as family differentiae (see table 8). An example is the coarse-loamy, siliceous, acid, thermic family of Typic Haplaquents.

SERIES. The series consists of a group of soils that formed in a particular kind of parent material and that have genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in their arrangement in the soil profile. Among these characteristics are color, texture, structure, consistence, reaction, and mineral and chemical composition.

Climate[7]

The climate of Canadian County varies from moist subhumid in the eastern section of the county to dry subhumid in the central and western sections. In a moist subhumid climate, the normal annual precipitation exceeds the amount of precipitation required for normal plant growth and development. In a dry subhumid climate,

[7] By BILLY R. CURRY, climatologist, National Weather Service, U.S. Department of Commerce.

there is a precipitation deficiency and, therefore, a need for some irrigation.

About 78 percent of the normal annual precipitation in Canadian County comes during the crop season (table 9), and most of it stems from thunderstorms, which frequently produce high-intensity rainfall. Thunderstorms occur on an average of 45 days during a normal 208-day growing season. There are normally 34 days during the growing season when rainfall is 0.10 inch or more, 25 days of 0.25 inch or more, 17 days of 0.50 inch or more, 8 days of 1 inch or more, and 2 days of more than 2 inches. Since 1941, the greatest 24-hour rainfall at El Reno was 7.08 inches, in September 1961. It is estimated that a 24-hour rainfall of 6.05 inches will occur on an average of once every 10 years, and a rainfall of 6.95 inches once every 25 years. A 1-hour rainfall of 2.85 inches is estimated to occur once every 10 years, and a 1-hour rainfall of 3.65 inches once every 25 years.

The normal seasonal snowfall in Canadian County is nearly 10 inches. There are 4 days in an average year when snowfall is 1 inch or more and about 7 days when snow cover is 1 inch or more. Since 1910, the greatest seasonal snowfall at El Reno was 28.5 inches in 1923–24.

Summer is normally hot. The average daily maximum temperature during the months of June, July, and August is 92° F. During summer on an average of 20 days the maximum temperature is 100° or higher. The record high temperature at El Reno is 114°, in August 1936.

The average winter is comparatively mild. A minimum temperature of 32° or below occurs 90 days in a normal year, and there are 7 days in a normal year when freezing temperatures continue throughout the day. Only eight times in the past 20 years have temperatures dropped to zero or below at El Reno. The record minimum temperature at El Reno is −15°, in February 1905.

The average last spring freeze at El Reno is on April 8, and the average first fall freeze is on November 2 (see table 10). Freezing temperatures have occurred as late as May 3 and as early as October 6.

The prevailing wind direction is southerly, but northerly and southerly winds occur with about equal frequency from December to March. The average monthly windspeed varies from 12 miles per hour in July and August to 16 miles per hour in March and April. Strong, gusty winds occur with thunderstorms and with low-pressure systems that migrate from west to east during winter and spring.

The average monthly relative humidity at 6 a.m. is 75 to 80 percent throughout the year; the average monthly relative humidity at 6 p.m. varies from about 45 percent in March, April, July, and August to 60 percent in December and January. An average of 140 clear days, 98 partly cloudy days, and 127 cloudy days provides Canadian County with 67 percent of the total possible sunshine.

Canadian County, like all of Oklahoma, is susceptible to severe storms. They occur more frequently during hot afternoons in spring, but can and have occurred in every month of the year and at every hour of the day. At any one location within the county, hail occurs on 5 days of an average year, although not all of the hailstorms are so intense that they cause damage to crops and property.

TABLE 9.—*Temperature and precipitation*

[All data from El Reno, Canadian County, for period of record 1941–70]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Average monthly maximum	Average monthly minimum	Average monthly total	One year in 10 will have —		Days that have snow cover of 1 inch or more	Average depth of snow on days that have snow cover
						Less than—	More than—		
	°F	°F	°F	°F	Inches	Inches	Inches	Number	Inches
January	49	26	70	6	0.9	0.1	2.3	3	2
February	54	30	75	12	1.2	.2	2.1	2	2
March	61	36	82	16	1.6	.5	3.2	1	3
April	73	48	89	30	2.9	1.1	6.3	0	0
May	81	57	93	41	5.1	1.6	10.4	0	0
June	89	66	98	53	3.9	1.3	6.3	0	0
July	94	70	102	58	2.6	.8	5.5	0	0
August	94	69	104	56	2.4	.2	3.9	0	0
September	86	61	99	46	3.4	.4	8.2	0	0
October	75	50	90	31	2.8	.3	7.7	0	0
November	62	37	78	19	1.5	[1]	4.3	0	0
December	52	29	71	10	1.2	.1	2.7	1	1
Year	73	48	[2] 105	[3] 3	29.5	21.1	35.9	7	2

[1] Trace.
[2] Average annual highest temperature.
[3] Average annual lowest temperature.

TABLE 10.—*Probabilities of last freezing temperatures in spring and first in fall*

[All data from El Reno, Canadian County; period of record 1921–68]

Probability	Dates for given probability and temperature				
	16° F	20° F	24° F	28° F	32° F
Spring:					
1 year in 10 later than	March 21	March 28	April 2	April 14	April 22
2 years in 10 later than	March 14	March 22	March 28	April 10	April 17
5 years in 10 later than	February 28	March 10	March 18	April 1	April 8
Fall:					
1 year in 10 earlier than	November 22	November 10	November 1	October 23	October 18
2 years in 10 earlier than	November 29	November 17	November 8	October 27	October 23
5 years in 10 earlier than	December 13	December 1	November 21	November 5	November 2

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Glossary

[Asterisks indicate terms used in tables 5 and 7]

ABC soil. A soil that has a complete profile, including an A, B, and C horizon.

AC soil. A soil that has an A horizon and a C horizon but no B horizon. Commonly such soils are immature, as those developing from alluvium or those on steep, rocky slopes.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Badlands. Areas of rough, irregular land where most of the surface is occupied by ridges, gullies, and deep channels. Land hard to traverse.

Base saturation. The degree to which material that has base-exchange properties is saturated with exchangeable cations other than hydrogen, expressed as a percentage of the cation-exchange capacity.

Bench terrace. A shelflike embankment of earth that has a level or nearly level top and a steep or nearly vertical downhill face, constructed along the contour of sloping land or across the slope to control runoff and erosion. The downhill face of the bench may be made of rocks or masonry, or it may be planted to vegetation.

Calcareous soil. A soil containing enough calcium carbonate (often with magenesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Capillary water. Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Chiseling. Tillage of soil with an implement having one or more soil penetrating points that loosen the subsoil and brings *clods* to the surface. A form of emerging tillage to control soil blowing.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

Climax vegetation. The stabilized plant community on a particular site; it reproduces itself and does not change so long as the environment does not change.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

***Compressible.** Excessive decrease in volume of soft soil under load.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

***Cut banks cave.** Unstable walls of cuts made by earthmoving equipment. This soil sloughs easily.

***Depth to rock.** Bedrock at a depth that adversely affects the specified use.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low available water capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Decreaser. Any of the climax range plants most heavily grazed. Because they are the most palatable, they are first to be destroyed by overgrazing.

Deferred grazing. The practice of delaying grazing until range plants have reached a definite stage of growth, in order to increase the vigor of the forage and to allow the desirable plants to produce seed. Contrasts with continuous grazing and rotation grazing.

Diversion, or diversion terrace. A ridge of earth, generally a terrace, that is built to divert runoff from its natural course and, thus, to protect areas downslope from the effects of such runoff.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

***Excess alkali.** Excess exchangeable sodium. The resulting poor physical properties restrict the growth of plants.

***Excess fines.** Excess silt and clay. The soil does not provide a source of gravel or sand for construction purposes.

Fallow. Cropland left idle in order to restore productivity, mainly through accumulation of water, nutrients, or both. Summer fallow is a common stage before cereal grain in regions of limited rainfall. The soil is tilled for at least one growing season to control weeds, to aid decomposition of plant residues, and to encourage the storage of moisture for the succeeding grain crop.

***Fast intake.** The rapid movement of water into the soil.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the oven-dry weight, after the gravitational, or free, water has been allowed to drain away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity.*

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Genesis, soil. The manner in which a soil originates. Refers especially to the processes initiated by climate and organisms that are responsible for the development of the solum, or true soil, from the unconsolidated parent material, as conditioned by relief and age of landform.

Gilgai. Typically, the microrelief of *Vertisols* -clayey soils that have a high coefficient of expansion and contraction with changes in moisture; usually a succession of microbasins and microknolls, in nearly level areas, or of microvalleys and microridges that run with the slope.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rains. The distinction between gully and rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by normal tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage. V-shaped gullies result if the material is more difficult to erode with depth; whereas U-shaped gullies result if the lower material is more easily eroded than that above it.

Gypsum. Calcium sulphate.

Hardpan. A hardened or cemented soil horizon, or layer. The soil material may be sandy or clayey, and it may be cemented by iron oxide, silica, calcium carbonate, or other substance.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Humus. The well-decomposed, more or less stable part of the organic matter in mineral soils.

Increasers. Species in the climax vegetation that increase in relative amount as the more desirable plants are reduced by close grazing; increasers commonly are shorter than decreasers, and some are less palatable to livestock.

Invaders. On range, plants that come in and grow after the climax vegetation has been reduced by grazing. Generally, invader plants are those that follow disturbance of the surface. (Most weeds are "invaders").

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state. In engineering, a high liquid limit indicates that the soil has a high content of clay and a low capacity for supporting loads.

Loess. Fine-grained material, dominantly of silt-sized particles, that has been deposited by wind.

***Low strength.** Inadequate strength for supporting loads.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and their thickness and arrangement in the soil profile.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

***Percs slowly.** The slow movement of water through the soil adversely affecting the specified use.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

pH value. A numerical means for designating acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

***Piping.** Formation by moving water of subsurface tunnels or pipelike cavities.

Plasticity index. The numercial difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from a semisolid to a plastic state.

Plowpan. A compacted layer formed in the soil immediately below the plowed layer.

Poorly graded. A soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles in poorly graded soil material, density can be increased only slightly by compaction.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Range condition. The state of health or productivity of both soil and forage in a given range, in terms of what productivity could or should be under normal climate and the best practical management. Condition classes generally recognized are—*excellent, good, fair,* and *poor.* The classification is based on the percentage of original, or climax, vegetation on the site, as compared to what ought to grow on it if management were good.

Range site. An area of range where climate, soil, and relief are sufficiently uniform to produce a distinct kind of climax vegetation.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Regolith. The unconsolidated mantle of weathered rock and soil material on the earth's surface; the loose earth material above the solid rock. Only the upper part of this, modified by organisms and other soil-building forces, is regarded by soil scientists as soil. Most American engineers speak of the whole regolith, even to great depths, as "soil."

Relief. The elevations or inequalities of a land surface, considered collectively.

Rill. A steep-sided channel resulting from accelerated erosion. A rill normally is a few inches in depth and width and is not large enough to be an obstacle to farm machinery.

***Rooting depth.** Shallow root zone. The soil is shallow over a layer that greatly restricts roots.

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

***Seepage.** The rapid movement of water through the soil. Seepage adversely affects the specified use.

***Shrink-swell.** The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silica. Silica is a combination of silicon and oxygen. The mineral form is called quartz.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on relatively steep slopes and in swelling clays, where there is marked change in moisture content.

Slickspots. Small areas in a field that are slick when wet because they contain excess exchangeable sodium, or alkali.

***Slow intake.** The slow movement of water into the soil.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows: *Very coarse sand* (2.0 to 1.0 millimeters); *coarse sand* (1.0 to 0.5 millimeter); *medium sand* (0.5 to 0.25 millimeter); *fine sand* (0.25 to 0.10 millimeter); *very fine sand* (0.10 to 0.05 millimeter); *silt* (0.05 to 0.002 millimeter); and *clay* (less than 0.002 millimeter). The separates recognized by the International Society of Soil Science are as follows: I (2.0 to 0.2 millimeter); II (0.2 to 0.02 millimeter); III (0.02 to 0.002 millimeter); IV (less than 0.002 millimeter.)

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular. Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles) adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizons; roughly, the part of the solum below low depth.

Subsoiling. Tillage of a soil below normal depth ordinarily to shatter a hardpan or claypan.

Substratum. Technically, the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loamy silt, clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

***Thin layer.** Otherwise suitable soil material too thin for the specified use.

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Topsoil. A presumed fertile soil or soil material, or one that responds to fertilization, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Trace elements. The chemical elements found in soils in extremely small amounts, yet which are essential to plant growth. Some of the trace elements are zinc, cobalt, manganese, copper, and iron.

***Unstable fill.** Risk of caving or sloughing in banks of fill material.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

Well-graded soil. A soil or soil material consisting of particles that are well distributed over a wide range in size or diameter. Such a soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wilting point (or permanent wilting point). The moisture content of soil, on an oven-dry basis, at which plants (specifically sunflower) wilt so much that they do not recover when placed in a dark, humid atmosphere.

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GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs.

Map symbol	Mapping unit	Page	Capability unit	Range site		Pasture and hay group	Tree group
				Name	Page		
BeA	Bethany silt loam, 0 to 1 percent slopes	6	I-2	Loamy Prairie	31	8A	7
BnC	Binger fine sandy loam, 1 to 5 percent slopes	6	IIIe-3	Sandy Prairie	32	8A	7
Br	Brewer silty clay loam	7	I-1	Heavy Bottomland	31	2A	4
Bu	Brewer-Drummond complex	7	IIIs-2	----------	--	---	4
	Brewer soil	--	------	Heavy Bottomland	31	2A	---
	Drummond soil	--	------	Saline Subirrigated	32	2C	---
Ca	Canadian fine sandy loam	7	I-1	Loamy Bottomland	31	2A	2
Da	Dale silt loam	8	I-1	Loamy Bottomland	31	2A	3
DnD	Darnell-Noble complex, 1 to 8 percent slopes	9	VIe-3	----------	--	---	8
	Darnell soil	--	------	Shallow Savannah	33	14A	---
	Noble soil	--	------	Sandy Savannah	32	8A	---
DnF	Darnell-Noble complex, 8 to 30 percent slopes	9	VIIe-2	----------	--	---	8
	Darnell soil	--	------	Shallow Savannah	33	---	---
	Noble soil	--	------	Sandy Savannah	32	---	---
DuD	Dill-Quinlan complex, 5 to 8 percent slopes	9	IVe-5	----------	--	---	8
	Dill soil	--	------	Sandy Prairie	32	8A	---
	Quinlan soil	--	------	Shallow Prairie	33	14A	---
Ga	Gracemore loamy fine sand, occasionally flooded	10	IIIe-4	Subirrigated	34	3B	1
Gb	Gracemore soils, frequently flooded	10	Vw-1	Subirrigated	34	3B	1
GdB	Grandfield fine sandy loam, 1 to 3 percent slopes	11	IIe-2	Sandy Prairie	32	8A	7
GdC	Grandfield fine sandy loam, 3 to 5 percent slopes	11	IIIe-3	Sandy Prairie	32	8A	7
GdC2	Grandfield fine sandy loam, 2 to 6 percent slopes, eroded	11	IVe-6	Sandy Prairie	32	8A	7
GdD	Grandfield fine sandy loam, 5 to 8 percent slopes	11	IVe-5	Sandy Prairie	32	8A	7
GdD3	Grandfield soils, 3 to 8 percent slopes, severely eroded	11	VIe-2	Eroded Prairie	31	8F	9
GhB	Grant-Hinkle complex, 1 to 3 percent slopes	12	IIIs-1	----------	--	---	7
	Grant soil	--	------	Loamy Prairie	31	8A	---
	Hinkle soil	--	------	Slickspot	34	8D	---
GpE	Grant-Port complex, 0 to 12 percent slopes	12	VIe-1	----------	--	---	7
	Grant soil	--	------	Loamy Prairie	31	8A	---
	Port soil	--	------	Loamy Bottomland	31	2A	---
GuD	Grant-Quinlan complex, 5 to 8 percent slopes	12	IVe-3	----------	--	---	8
	Grant soil	--	------	Loamy Prairie	31	8A	---
	Quinlan soil	--	------	Shallow Prairie	33	14A	---
GuD2	Grant-Quinlan complex, 3 to 8 percent slopes, eroded	12	IVe-4	----------	--	---	8
	Grant soil	--	------	Loamy Prairie	31	8A	---
	Quinlan soil	--	------	Shallow Prairie	33	14A	---
KfB	Kingfisher silt loam, 1 to 3 percent slopes	13	IIe-1	Loamy Prairie	31	8A	7
KfC	Kingfisher silt loam, 3 to 5 percent slopes	13	IIIe-2	Loamy Prairie	31	8A	7
KrA	Kirkland silt loam, 0 to 1 percent slopes	14	IIs-1	Claypan Prairie	30	8C	5
KrB	Kirkland silt loam, 1 to 3 percent slopes	14	IIIe-1	Claypan Prairie	30	8C	5
KsB	Kirkland-Hinkle complex, 0 to 3 percent slopes	14	IVs-1	----------	--	---	5
	Kirkland soil	--	------	Claypan Prairie	30	8C	---
	Hinkle soil	--	------	Slickspot	34	8D	---
KwD	Konawa loamy fine sand, 3 to 8 percent slopes	15	IVe-2	Deep Sand Savannah	30	9A	7
Mc	McLain silty clay loam	15	I-1	Heavy Bottomland	31	2A	4
MnD	Minco very fine sandy loam, 5 to 8 percent slopes	16	IVe-3	Loamy Prairie	31	8A	7

Map symbol	Mapping unit	Page	Capability unit	Range site		Pasture and hay group	Tree group
				Name	Page		
MnF	Minco very fine sandy loam, 8 to 30 percent slopes	16	VIe-4	Loamy Prairie	31	8A	7
MsB	Minco silt loam, 1 to 3 percent slopes	16	IIe-1	Loamy Prairie	31	8A	7
MsC	Minco silt loam, 3 to 5 percent slopes	16	IIIe-2	Loamy Prairie	31	8A	7
NaD	Nash-Quinlan complex, 3 to 8 percent slopes	16	IVe-3	----------	--	---	8
	Nash soil	--	------	Loamy Prairie	31	8A	---
	Quinlan soil	--	------	Shallow Prairie	33	14A	---
NaD2	Nash-Quinlan complex, 3 to 8 percent slopes, eroded	17	IVe-4	----------	--	---	8
	Nash soil	--	------	Loamy Prairie	31	8A	---
	Quinlan soil	--	------	Shallow Prairie	33	14A	---
NaD3	Nash-Quinlan complex, 3 to 8 percent slopes, severely eroded	17	VIe-2	Eroded Prairie	31	8F	9
NbC	Noble fine sandy loam, 3 to 5 percent slopes	17	IIIe-3	Sandy Savannah	32	8A	7
NrB	Norge silt loam, 1 to 3 percent slopes	18	IIe-1	Loamy Prairie	31	8A	7
NrC	Norge silt loam, 3 to 5 percent slopes	19	IIIe-2	Loamy Prairie	31	8A	7
NrD	Norge silt loam, 5 to 8 percent slopes	19	IVe-3	Loamy Prairie	31	8A	7
PkA	Pond Creek silt loam, 0 to 1 percent slopes	19	I-2	Loamy Prairie	31	8A	7
PkB	Pond Creek silt loam, 1 to 3 percent slopes	19	IIe-1	Loamy Prairie	31	8A	7
Po	Port silt loam	20	IIw-1	Loamy Bottomland	31	2A	3
Pw	Port soils, frequently flooded	20	Vw-2	Loamy Bottomland	31	2A	3
QdE	Quinlan-Dill complex, 5 to 12 percent slopes	20	VIe-5	----------	--	---	8
	Quinlan soil	--	------	Shallow Prairie	33	14A	---
	Dill soil	--	------	Sandy Prairie	32	8A	---
QrF	Quinlan-Rock outcrop complex, 12 to 30 percent slopes	21	VIIs-1	----------	--	---	9
	Quinlan soil	--	------	Breaks	30	---	---
	Rock outcrop	--	------	----------	--	---	---
Ra	Reinach very fine sandy loam	21	I-1	Loamy Bottomland	31	2A	3
RbA	Renfrow silt loam, 0 to 1 percent slopes	22	IIs-1	Claypan Prairie	30	8C	5
RbB	Renfrow silt loam, 1 to 3 percent slopes	22	IIIe-1	Claypan Prairie	30	8C	5
RcC2	Renfrow clay loam, 2 to 5 percent slopes, eroded	22	IVe-1	Claypan Prairie	30	8C	5
ShB	Shellabarger fine sandy loam, 1 to 3 percent slopes	22	IIe-2	Sandy Prairie	32	8A	7
ShC	Shellabarger fine sandy loam, 3 to 5 percent slopes	23	IIIe-3	Sandy Prairie	32	8A	7
ShD	Shellabarger fine sandy loam, 5 to 8 percent slopes	23	IVe-5	Sandy Prairie	32	8A	7
ShD2	Shellabarger fine sandy loam, 3 to 8 percent slopes, eroded	23	IVe-6	Sandy Prairie	32	8A	7
SnE	Shellabarger-Albion complex, 5 to 12 percent slopes	23	VIe-6	Sandy Prairie	32	8A	7
Tv	Tivoli fine sand	23	VIIe-1	Dune	31	---	6
VeC	Vernon clay loam, 3 to 5 percent slopes	24	IVe-1	Red Clay Prairie	32	7A	8
VrE	Vernon-Rock outcrop complex, 5 to 15 percent slopes	24	VIIs-2	----------	--	---	---
	Vernon soil	--	------	Red Clay Prairie	32	---	9
	Rock outcrop	--	------	----------	--	---	---
VsC2	Vernon soils, 3 to 5 percent slopes, eroded	24	VIe-7	Red Clay Prairie	32	7A	8
Wa	Watonga silty clay	24	IIIw-1	Heavy Bottomland	31	1A	4
Ya	Yahola fine sandy loam	25	IIw-1	Loamy Bottomland	31	2A	2

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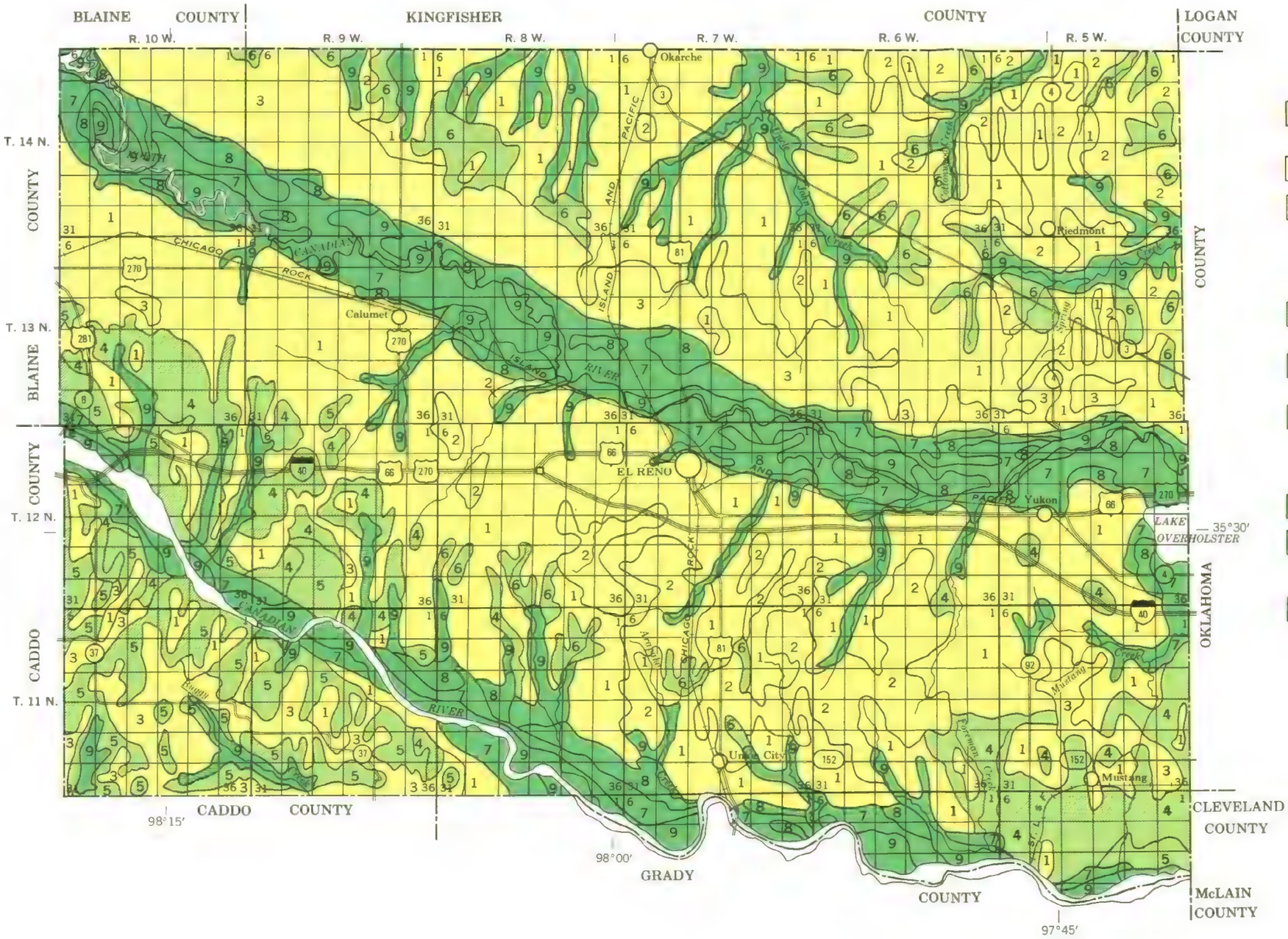

SOIL ASSOCIATIONS *

DEEP, WELL–DRAINED LOAMY AND SANDY SOILS ON UPLANDS

1 — NORGE–BETHANY association: Deep, well drained, nearly level to sloping loamy soils that have a clayey and loamy subsoil

2 — RENFROW–KIRKLAND association: Deep, well drained, nearly level to gently sloping loamy soils that have a clayey subsoil

3 — SHELLABARGER–KONAWA association: Deep, well drained very gently sloping to strongly sloping loamy and sandy soils that have a loamy subsoil

SHALLOW TO DEEP, WELL DRAINED AND SOMEWHAT EXCESSIVELY DRAINED LOAMY AND CLAYEY SOILS ON UPLANDS

4 — NASH–QUINLAN association: Moderately deep and shallow, well drained, gently sloping to steep loamy soils that have a loamy subsoil

5 — DARNELL–MINCO association: Shallow and deep, somewhat excessively drained and well drained, very gently sloping to steep loamy soils that have a loamy subsoil

6 — VERNON association: Moderately deep, well drained, gently sloping to moderately steep clayey and loamy soils that have a clayey subsoil

DEEP, WELL DRAINED TO SOMEWHAT POORLY DRAINED CLAYEY TO SANDY SOILS ON FLOOD PLAINS

7 — DALE–CANADIAN association: Deep, well drained, nearly level loamy soils that have a loamy subsoil

8 — WATONGA–BREWER association: Deep, moderately well drained, nearly level soils that are dominantly clayey throughout and loamy soils that have a loamy and clayey subsoil

9 — PORT–GRACEMORE association: Deep, well drained and somewhat poorly drained, nearly level loamy and sandy soils that have a loamy subsoil and sandy and loamy underlying material

* Texture refers to the surface layer of the major soils in the association.

Compiled 1975

N

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

OKLAHOMA AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP

CANADIAN COUNTY, OKLAHOMA

Scale 1:253,440

1 0 1 2 3 4 Miles

INDEX TO MAP SHEETS

CANADIAN COUNTY, OKLAHOMA

Scale 1:253,440

1 0 1 2 3 4 Miles

SOIL LEGEND

The first letter, always a capital, is the initial letter of the soil name. The second letter is a samll letter. The third letter, always a capital, shows the slope. Most symbols without slope letters are those of nearly level soils. A final number, 2 or 3 in the symbol shows that the soil has been eroded.

SYMBOL	NAME
BeA	Bethany silt loam, 0 to 1 percent slopes
BnC	Binger fine sandy loam, 1 to 5 percent slopes
Br	Brewer silty clay loam
Bu	Brewer-Drummond complex
Ca	Canadian fine sandy loam
Da	Dale silt loam
DnD	Darnell-Noble complex, 1 to 8 percent slopes
DnF	Darnell-Noble complex, 8 to 30 percent slopes
DuD	Dill-Quinlan complex, 5 to 8 percent slopes
Ga	Gracemore loamy fine sand, occasionally flooded
Gb	Gracemore soils, frequently flooded
GdB	Grandfield fine sandy loam, 1 to 3 percent slopes
GdC	Grandfiled fine sandy loam, 3 to 5 percent slopes
GdC2	Grandfield fine sandy loam, 2 to 6 percent slopes, eroded
GdD	Grandfield fine sandy loam, 5 to 8 percent slopes
GdD3	Grandfield soils, 3 to 8 percent slopes, severely eroded
GhB	Grant-Hinkle complex, 1 to 3 percent slopes
GpE	Grant-Port complex, 0 to 12 percent slopes
GuD	Grant-Quinlan complex, 5 to 8 percent slopes
GuD2	Grant-Quinlan complex, 3 to 8 percent slopes, eroded
KfB	Kingfisher silt loam, 1 to 3 percent slopes
KfC	Kingfisher silt loam, 3 to 5 percent slopes
KrA	Kirkland silt loam, 0 to 1 percent slopes
KrB	Kirkland silt loam, 1 to 3 percent slopes
KsB	Kirkland-Hinkle complex, 0 to 3 percent slopes
KwD	Konawa loamy fine sand, 3 to 8 percent slopes
Mc	McLain silty clay loam
MnD	Minco very fine sandy loam, 5 to 8 percent slopes
MnF	Minco very fine sandy loam, 8 to 30 percent slopes
MsB	Minco silt loam, 1 to 3 percent slopes
MsC	Minco silt loam, 3 to 5 percent slopes
NaD	Nash-Quinlan complex, 3 to 8 percent slopes
NaD2	Nash-Quinlan complex, 3 to 8 percent slopes, eroded
NaD3	Nash-Quinlan complex, 3 to 8 percent slopes, severely eroded
NbC	Noble fine sandy loam, 3 to 5 percent slopes
NrB	Norge silt loam, 1 to 3 percent slopes
NrC	Norge silt loam, 3 to 5 percent slopes
NrD	Norge silt loam, 5 to 8 percent slopes
PkA	Pond Creek silt loam, 0 to 1 percent slopes
PkB	Pond Creek silt loam, 1 to 3 percent slopes
Po	Port silt loam
Pw	Port soils, frequently flooded
QdE	Quinlan-Dill complex, 5 to 12 percent slopes
QrF	Quinlan-Rock outcrop complex, 12 to 30 percent slopes
Ra	Reinach very fine sandy loam
RbA	Renfrow silt loam, 0 to 1 percent slopes
RbB	Renfrow silt loam, 1 to 3 percent slopes
RcC2	Renfrow clay loam, 2 to 5 percent slopes, eroded
ShB	Shellabarger fine sandy loam, 1 to 3 percent slopes
ShC	Shellabarger fine sandy loam, 3 to 5 percent slopes
ShD	Shellabarger fine sandy loam, 5 to 8 percent slopes
ShD2	Shellabarger fine sandy loam, 3 to 8 percent slopes, eroded
SnE	Shellabarger-Albion complex, 5 to 12 percent slopes
Tv	Tivoli fine sand
VeC	Vernon clay loam, 3 to 5 percent slopes
VrE	Vernon-Rock outcrop complex, 5 to 15 percent slopes
VsC2	Vernon soils, 3 to 5 percent slopes, eroded
Wa	Watonga silty clay
Ya	Yahola fine sandy loam

CONVENTIONAL AND SPECIAL SYMBOLS LEGEND

CULTURAL FEATURES

BOUNDARIES

- National, state or province
- County or parish
- Minor civil division
- Reservation (national forest or park, state forest or park, and large airport)
- Land grant
- Limit of soil survey (label)
- Field sheet matchline & neatline

AD HOC BOUNDARY (label)

- Small airport, airfield, park, oilfield, cemetery, or flood pool

STATE COORDINATE TICK

LAND DIVISION CORNERS (sections and land grants)

ROADS

- Divided (median shown if scale permits)
- Other roads
- Trail

ROAD EMBLEMS & DESIGNATIONS

- Interstate
- Federal
- State
- County, farm or ranch

RAILROAD

POWER TRANSMISSION LINE (normally not shown)

PIPE LINE (normally not shown)

FENCE (normally not shown)

LEVEES

- Without road
- With road
- With railroad

DAMS

- Large (to scale)
- Medium or small

PITS

- Gravel pit
- Mine or quarry

MISCELLANEOUS CULTURAL FEATURES

- Farmstead, house (omit in urban areas)
- Church
- School
- Indian mound (label)
- Located object (label)
- Tank (label)
- Wells, oil or gas
- Windmill
- Kitchen midden

WATER FEATURES

DRAINAGE

- Perennial, double line
- Perennial, single line
- Intermittent
- Drainage end
- Canals or ditches
  - Double-line (label)
  - Drainage and/or irrigation

LAKES, PONDS AND RESERVOIRS

- Perennial
- Intermittent

MISCELLANEOUS WATER FEATURES

- Marsh or swamp
- Spring
- Well, artesian
- Well, irrigation
- Wet spot

SPECIAL SYMBOLS FOR SOIL SURVEY

SOIL DELINEATIONS AND SYMBOLS

ESCARPMENTS

- Bedrock (points down slope)
- Other than bedrock (points down slope)

SHORT STEEP SLOPE

GULLY

DEPRESSION OR SINK

SOIL SAMPLE SITE (normally not shown)

MISCELLANEOUS

- Blowout
- Clay spot
- Gravelly spot
- Gumbo, slick or scabby spot (sodic)
- Dumps and other similar non soil areas
- Prominent hill or peak
- Rock outcrop (includes sandstone and shale)
- Saline spot
- Sandy spot
- Severely eroded spot
- Slide or slip (tips point upslope)
- Stony spot, very stony spot
- Borrow pit

CANADIAN COUNTY, OKLAHOMA — SHEET NUMBER 1

1 910 000 FEET

R. 10 W.

BLAINE COUNTY

260 000 FEET

T. 14 N.

BLAINE COUNTY

NORTH CANADIAN RIVER

(Joins sheet 2)

(Joins sheet 9)

1 930 000 FEET

250 000 FEET

N

1 Mile

5000 Feet

Scale 1:20000

This map is compiled on 19[illegible] aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

This map was compiled on 1971 aerial photography by the U. S. Department of Agriculture Soil Conservation Service and cooperating agencies
Coordinate grid ticks and division corners of sections are approximately positioned

KINGFISHER COUNTY

R. 9 W. | R. 8 W.

1 955 000 FEET

260 000 FEET

T. 14 N.

(Joins sheet 2)

(Joins sheet 4)

(Joins sheet 11)

1 975 000 FEET

250 000 FEET

3

N

1 Mile

5000 Feet

Scale 1:20000

(4)

N

R. 8 W. KINGFISHER COUNTY

2 000 000 FEET

260 000 FEET

T. 14 N.

1 980 000 FEET

250 000 FEET

(Joins sheet 3)

(Joins sheet 5)

(Joins sheet 12)

1 Mile 5 000 Feet

Scale - 1 : 20000

1 ½ 0 0 ¼ ½ ¾ 1

5000 4000 3000 2000 1000 0

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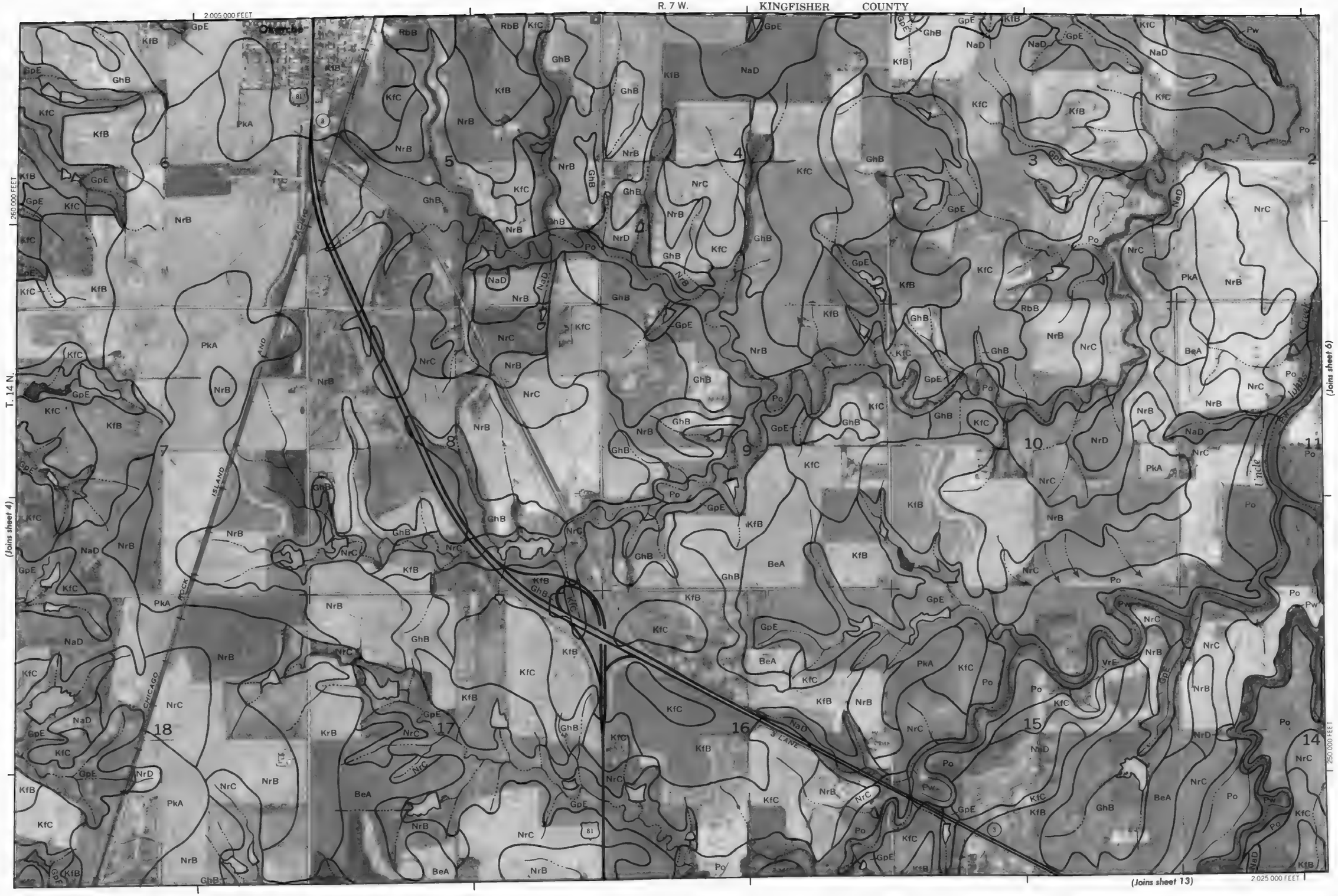

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(8)

N

R. 5 W.

KINGFISHER COUNTY

LOGAN COUNTY

2 095 000 FEET

T. 14 N.

OKLAHOMA COUNTY

250 000 FEET

2 075 000 FEET

(Joins sheet 7)

(Joins sheet 16)

1 Mile

5000 Feet

Scale · 1 : 20000

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Coordinate grid ticks and land division corners if shown are approximately positioned

1 910 000 FEET

R. 10 W.

(Joins sheet 1)

245 000 FEET

T. 14 N.

BLAINE COUNTY

NORTH CANADIAN RIVER

CHICAGO, ROCK ISLAND AND PACIFIC

(Joins sheet 10)

235 000 FEET

1 930 000 FEET

(Joins sheet 17)

N

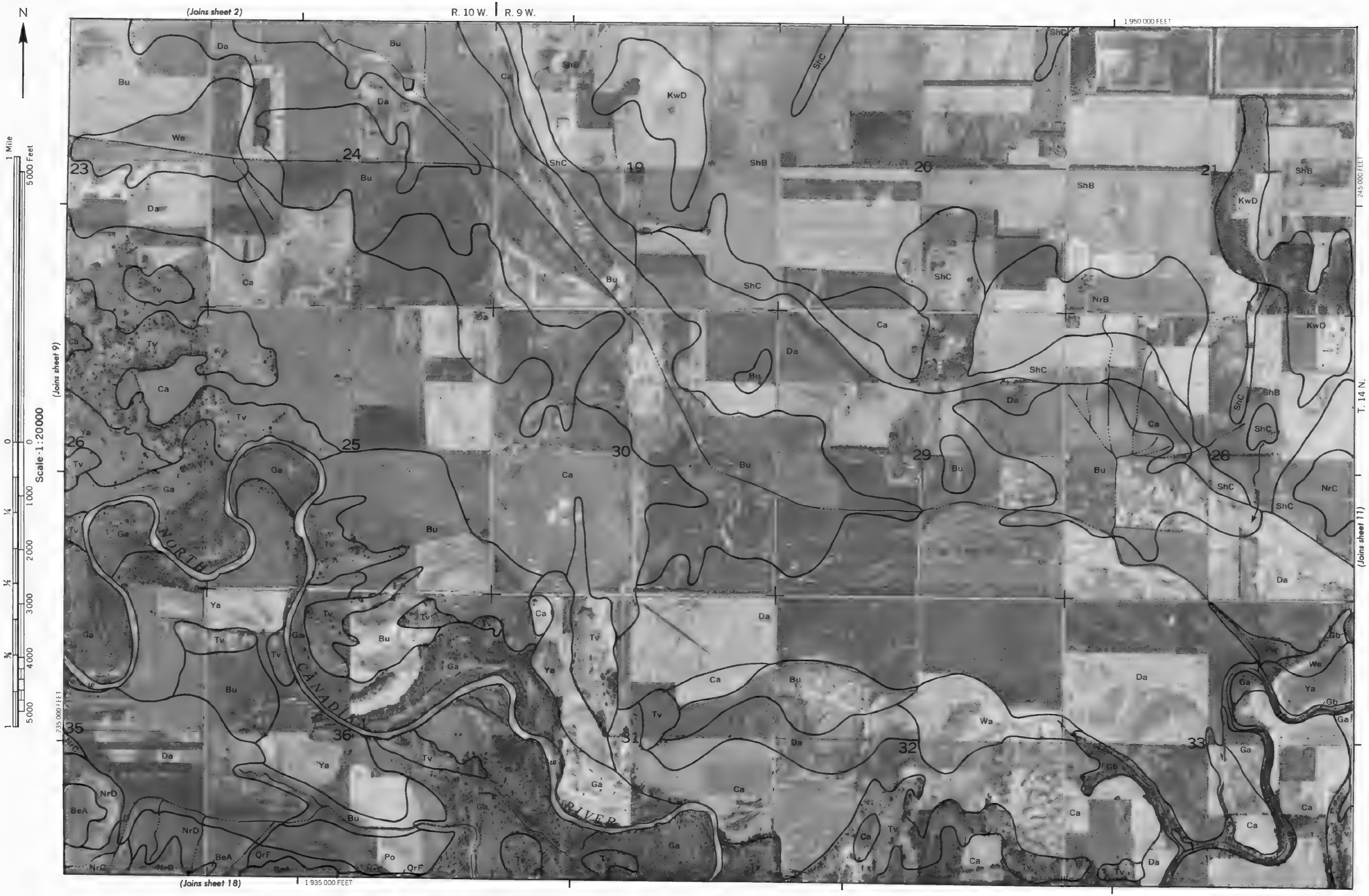
1 Mile

5000 Feet

0 1 000 2000 3000 4000 5000

Scale 1:20000

CANADIAN COUNTY, OKLAHOMA — SHEET NUMBER 10



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Coordinate grid ticks and land division corners, if shown, are approximately positioned.

11

N

R. 9 W. | R. 8 W.

(Joins sheet 3)

1 955 000 FEET

245 000 FEET

T. 14 N.

(Joins sheet 10)

(Joins sheet 12)

(Joins sheet 19)

1 975 000 FEET

235 000 FEET

1 Mile

5000 Feet

Scale 1:20000

0 1000 2000 3000 4000 5000

1/4 1/2 3/4 1

22 23 24 19 20

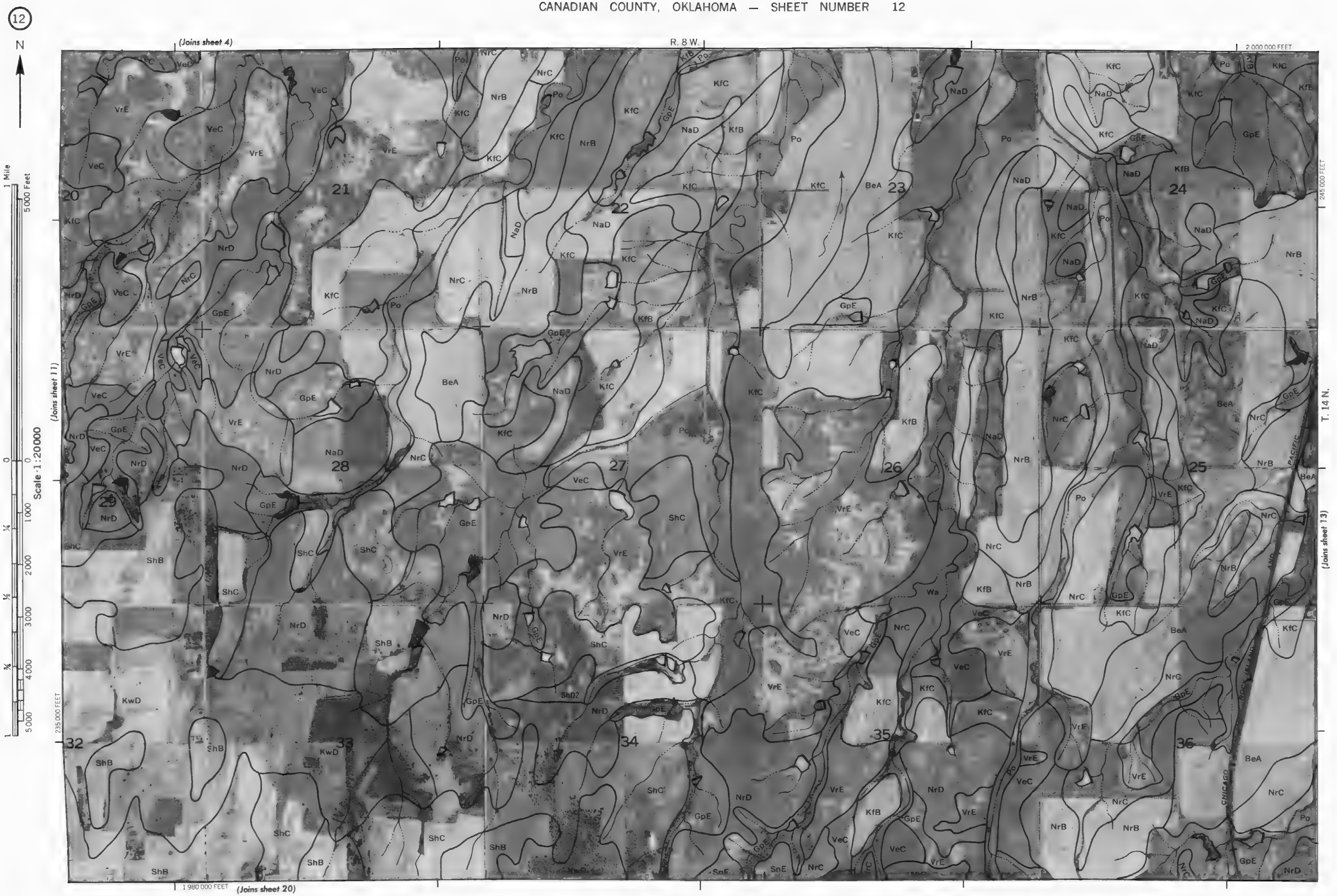
27 26 25 30 29

34 35 36 31 32

1 2

ShB KwD ShC NrD NrC NrB Po RbB KfC VrE NaD VeC KfB GpE VsC2 Da Ga Gb Ca Ya Tv

NC RIVER



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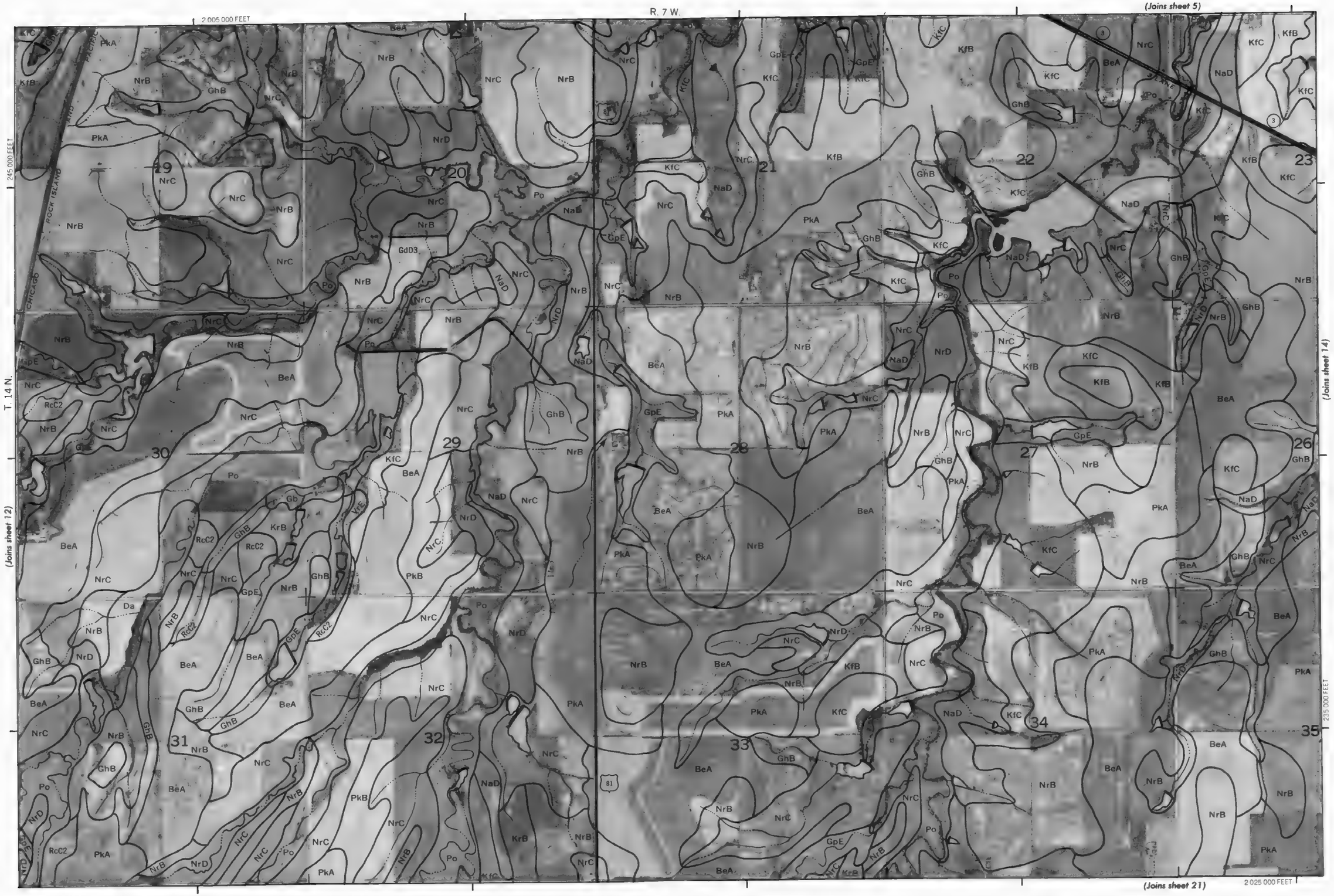

N

1 Mile

5000 Feet

0 0

Scale · 1:20000

1 000 2000 3000 4000 5000

¼ ½ ¾ 1

(Joins sheet 6)

R. 7 W. | R. 6 W.

2 045 000 FEET

245 000 FEET

T. 14 N.

(Joins sheet 13)

(Joins sheet 15)

235 000 FEET

(Joins sheet 22)

2 030 000 FEET

Uncle Johns Creek

3 LANE

23 24 19 20 21

26 25 30 29 28

35 36 31 32 33

NrC NrB NrD Po KfB KfC GpE GhB NaD BeA RbA PkA RbB RcC2 KrB PW VsC2 GdD3 Ca

15

N

R. 6 W. | R. 5 W.

(Joins sheet 7)

2 050 000 FEET

2 070 000 FEET

T. 14 N.

(Joins sheet 14)

(Joins sheet 23)

(Joins sheet 16)

235 000 FEET

241 000 FEET

Piedmont

Scale 1:20000

1 Mile 5000 Feet

N

(Joins sheet 8)

R. 5 W.

2 095 000 FEET

T. 14 N.

245 000 FEET

(Joins sheet 15)

235 000 FEET

2 075 000 FEET (Joins sheet 24)

Scale 1:20000

1 Mile 5 000 Feet

0 0 ¼ ½ ¾ 1

1000 2000 3000 4000 5000

Piedmont

Soldier Creek

OKLAHOMA COUNTY

1 910 000 FEET

R. 10 W.

(Joins sheet 9)

230 000 FEET

T. 13 N.

BLAINE COUNTY

Coyote Hills

ROCK ISLAND AND PACIFIC (NRB)

CHICAGO ROCK ISLAND AND Over PACIFIC

BeA NrC NrB GuD GuD2 QdE QrF PkB GhB NrD GuE DuD GpE MsB MsC ShC ShB MnD

(Joins sheet 18)

(Joins sheet 25)

1 930 000 FEET

220 000 FEET

N

1 Mile

5000 Feet

Scale 1:20000

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19

N

1 Mile

5000 Feet

0 0

Scale 1:20000

1 ½ ¼ 1000 2000 3000 4000 5000

CANADIAN COUNTY, OKLAHOMA — SHEET NUMBER 20

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N

(Joins sheet 14)

R. 7 W. | R. 6 W.

2 045 000 FEET

230 000 FEET

T. 13 N.

(Joins sheet 21)

(Joins sheet 23)

220 000 FEET

2 030 000 FEET

(Joins sheet 30)

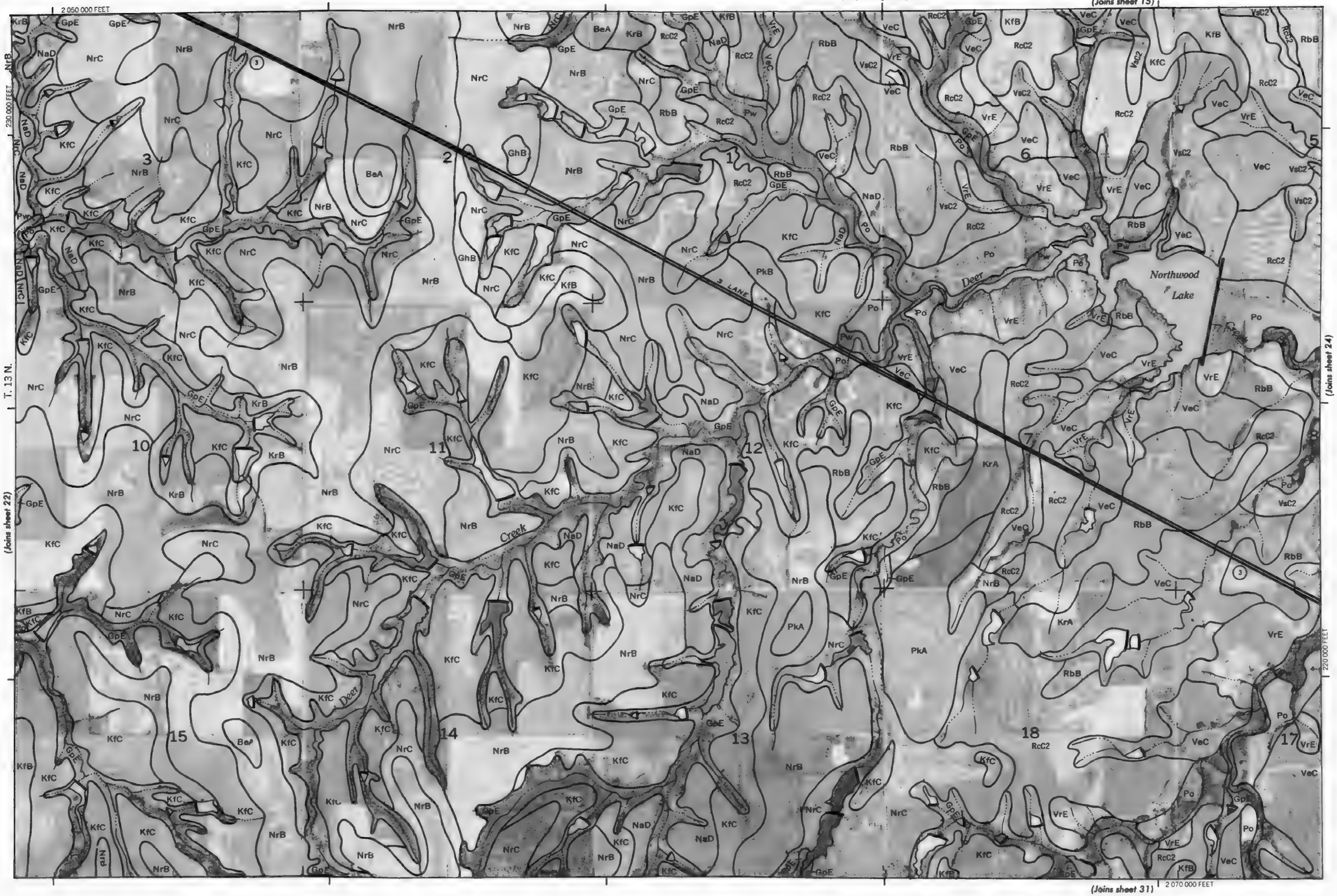
1 Mile

5000 Feet

Scale 1:20000

0 ¼ ½ ¾ 1

0 1000 2000 3000 4000 5000



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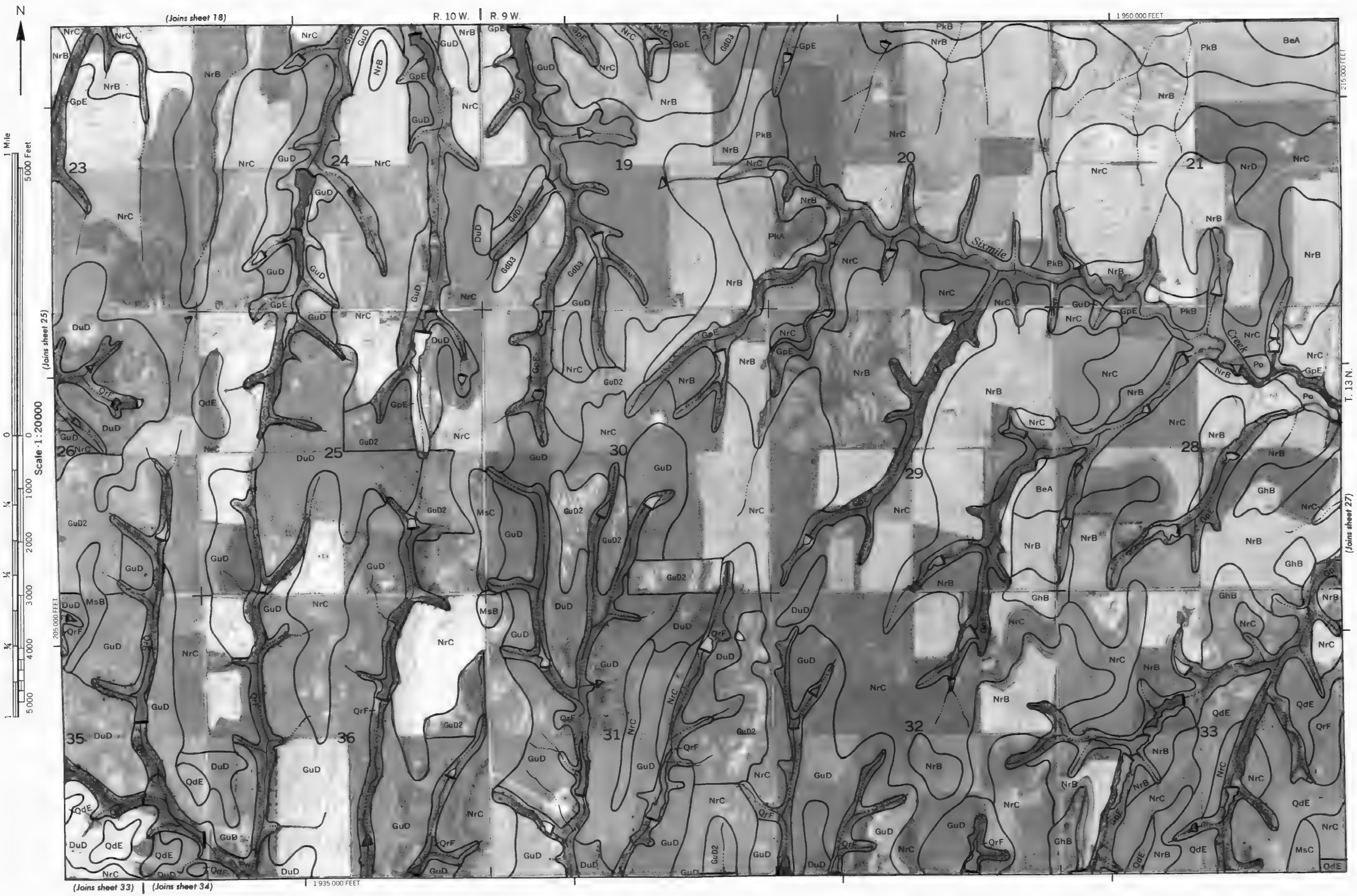
N
(Joins sheet 18)
R. 10 W.
R. 9 W.
1 950 000 FEET
215 000 FEET
(Joins sheet 25)
T. 13 N.
(Joins sheet 27)
205 000 FEET
1 935 000 FEET
(Joins sheet 33)
(Joins sheet 34)
1 Mile
5000 Feet
Scale 1:20000
Sixmile
Creek
19
20
21
23
24
25
26
28
29
30
31
32
33
35
36

N

R. 9 W. | R. 8 W.

1 955 000 FEET

215 000 FEET

T. 13 N.

(Joins sheet 19)

(Joins sheet 26)

(Joins sheet 28)

205 000 FEET

1 975 000 FEET

(Joins sheet 34) | (Joins sheet 35)

CHICAGO — ROCK ISLAND AND PACIFIC

Sixmile Creek

Scale 1:20000

1 Mile

5000 Feet

N

(Joins sheet 20)

R. 8 W.

2 000 000 FEET

215 000 FEET

T. 13 N.

(Joins sheet 29)

205 000 FEET

1 980 000 FEET

(Joins sheet 35) | (Joins sheet 36)

1 Mile

5000 Feet

Scale 1:20000

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Coordinate grid ticks and land division corners (if shown) are approximately positioned

2 005 000 FEET

215 000 FEET

R. 7 W.

(Joins sheet 21)

T. 13 N.

(Joins sheet 28)

(Joins sheet 30)

205 000 FEET

2 025 000 FEET

(Joins sheet 36)

(Joins sheet 37)

29

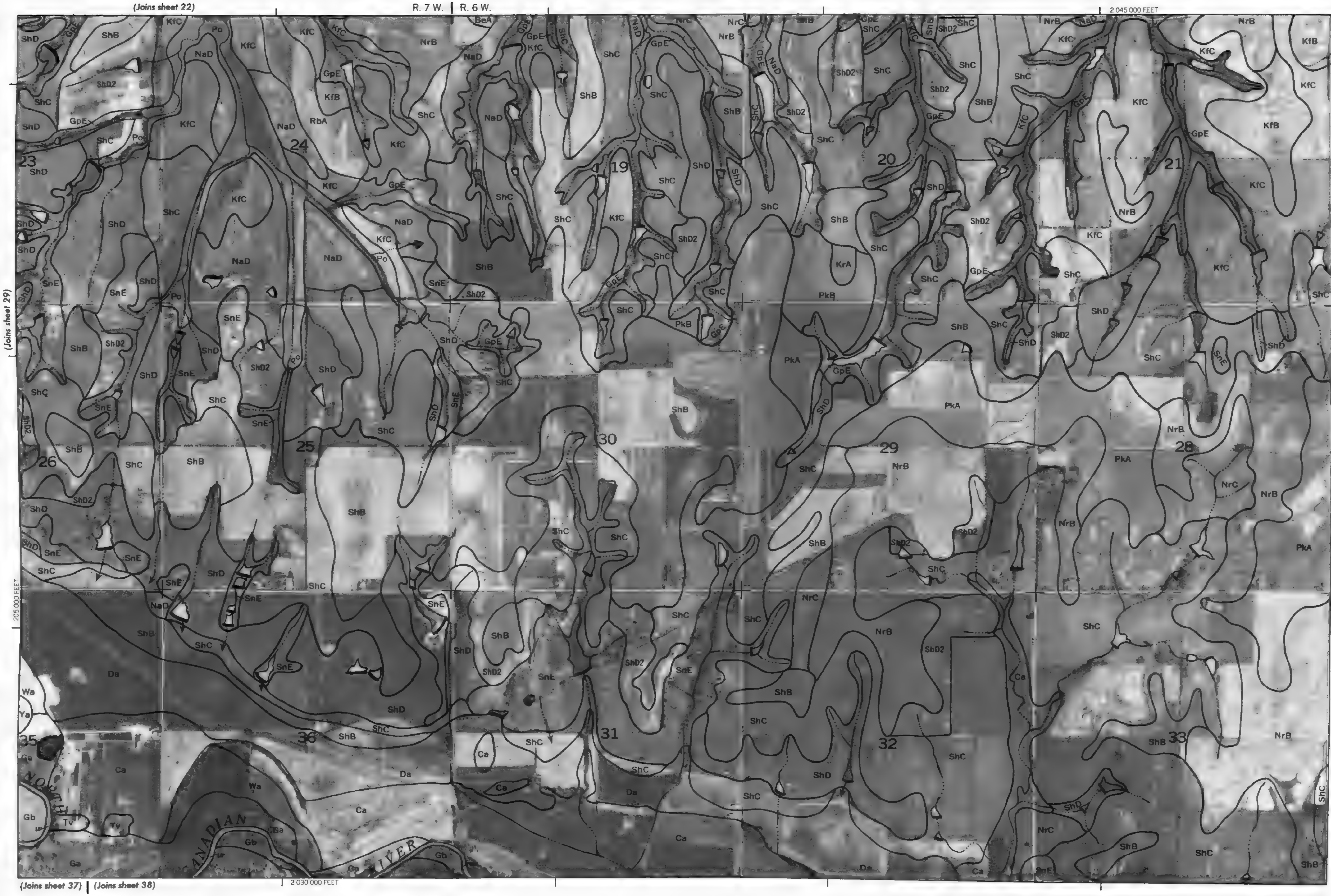
N

1 Mile

5000 Feet

Scale 1:20000

N



1 Mile
5000 Feet
Scale 1:20000
0 ¼ ½ ¾
0 1000 2000 3000 4000 5000

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R. 6 W. | R. 5 W.

(Joins sheet 23)

2 050 000 FEET

215 000 FEET

T. 13 N.

(Joins sheet 32)

(Joins sheet 30)

205 000 FEET

2 070 000 FEET

(Joins 38) | (Joins sheet 39)

Richland

N

1 Mile

5000 Feet

Scale 1:20000

N

(Joins sheet 24)

R. 5 W.

2 095 000 FEET

215 000 FEET

T. 13 N.

OKLAHOMA COUNTY

(Joins sheet 31)

205 000 FEET

1 Mile

5000 Feet

0 0

Scale 1:20000

1 5000 ¾ 4000 ½ 3000 ¼ 2000 1000 0

2 075 000 FEET

(Joins 39) | (Joins sheet 40)

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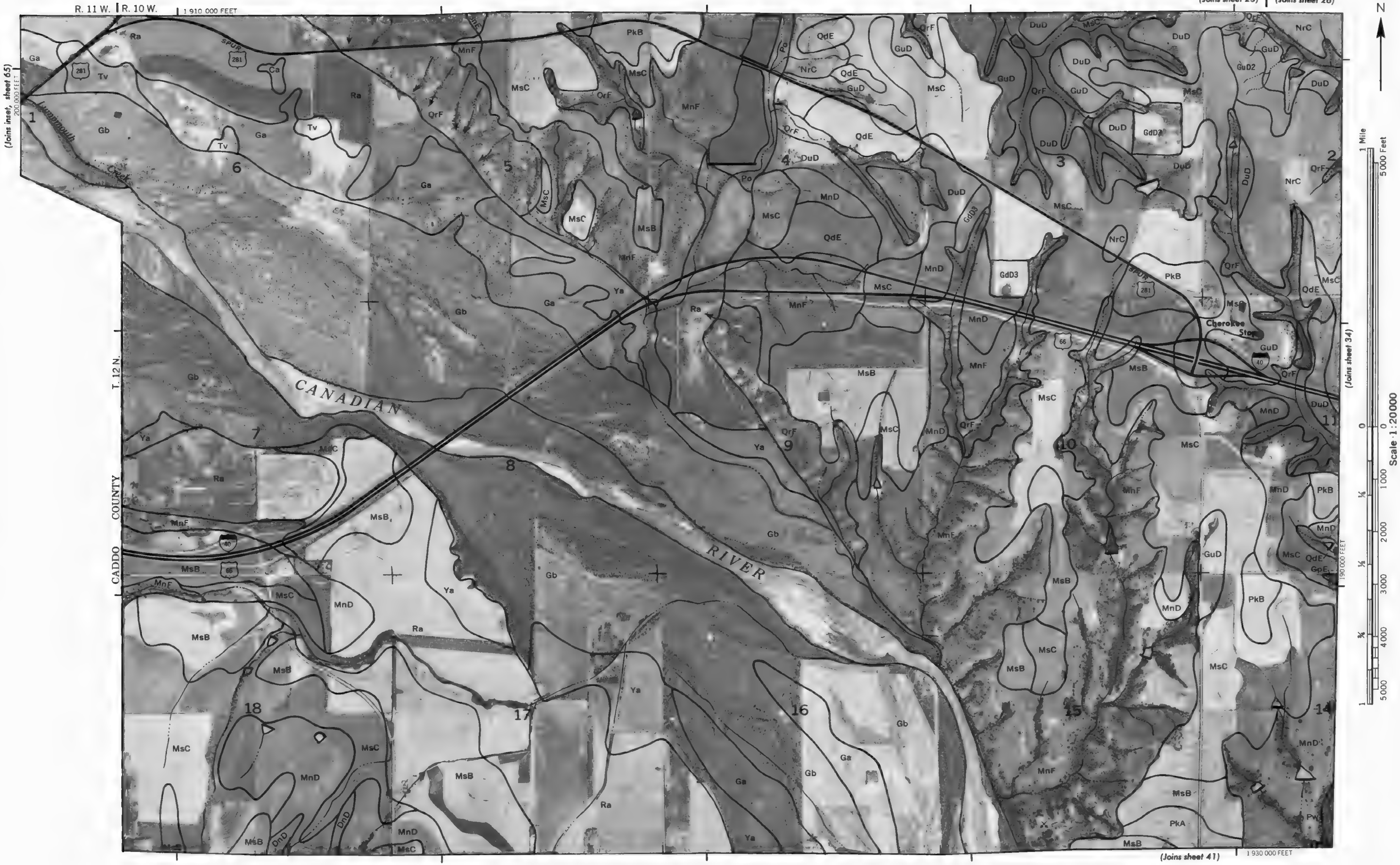

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34

N

R. 10 W. | R. 9 W.

(Joins sheet 26) | (Joins sheet 27)

1 955 000 FEET

200 000 FEET

T. 12 N.

(Joins sheet 33)

(Joins sheet 35)

1 935 000 FEET

(Joins sheet 42)

Scale · 1:20000

1 Mile 5000 Feet

0 0 ¼ ½ ¾ 1 000 2000 3000 4000 5000

Powder Face

CANYON

TALI

1 960 000 FEET

R. 9 W. | R. 8 W.

(Joins sheet 27) | (Joins sheet 28)

200 000 FEET

T. 12 N.

(Joins sheet 34)

(Joins sheet 36)

1 975 000 FEET

(Joins sheet 43)

185 000 FEET

N

1 Mile

5000 Feet

Scale 1:20000

N

R. 8 W.

(Joins sheet 28) | (Joins sheet 29)

2 000 000 FEET

200 000 FEET

T. 12 N.

1 Mile

5 000 Feet

Scale 1:20000

0 0

1000 2000 3000 4000 5000

¼ ½ ¾ 1

(Joins sheet 35)

Oklahoma State University of Agriculture and Applied Science Experimental Station

Prison Lake

US Reformatory

water

Lake El Reno

Turner Creek

Fourmile Creek

(Joins sheet 37)

185 000 FEET

1 980 000 FEET

(Joins sheet 44)

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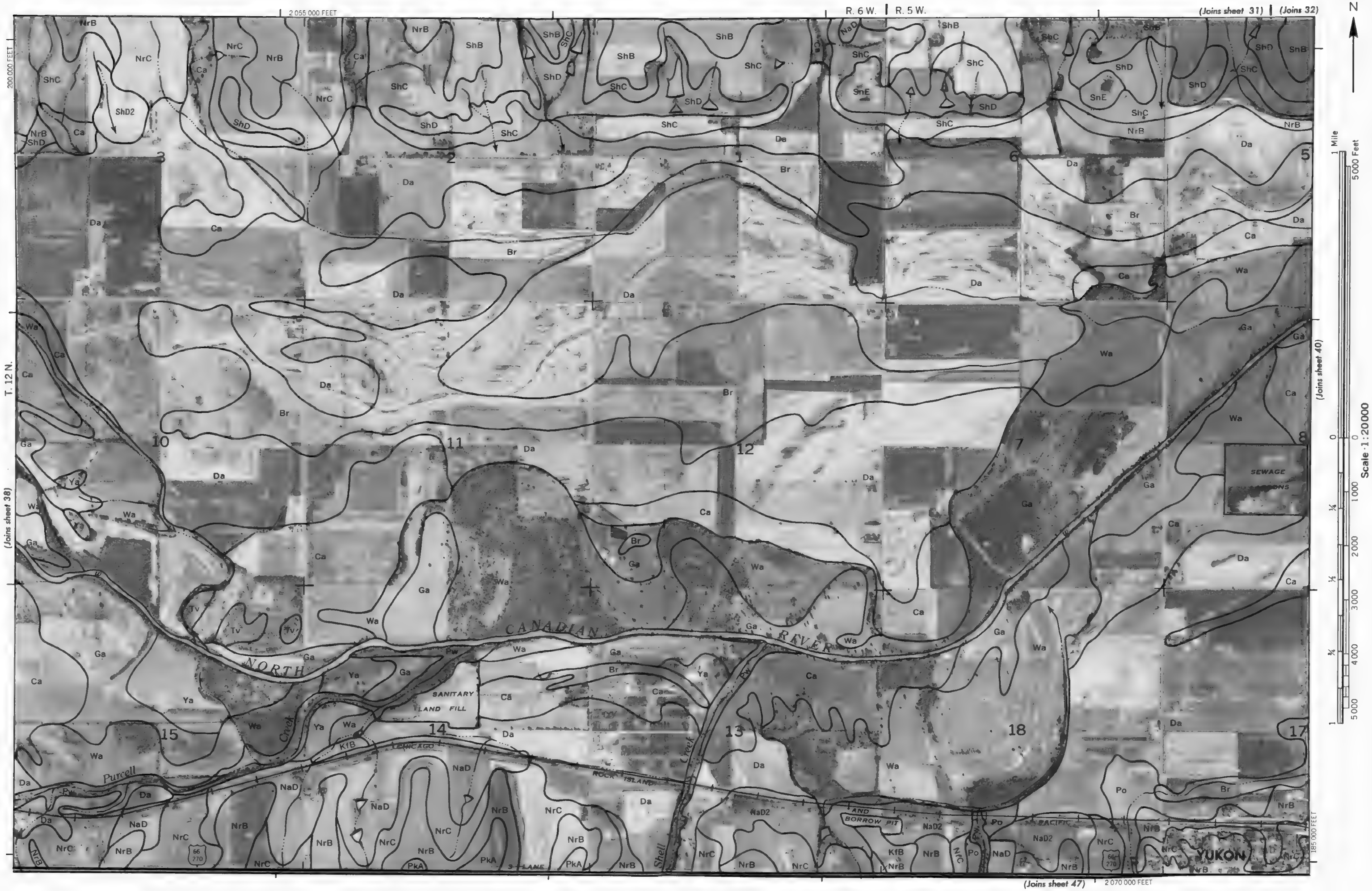
N
R. 7 W.
R. 6 W.
(Joins sheet 30)
(Joins sheet 31)
(Joins sheet 37)
(Joins sheet 39)
(Joins sheet 46)
T. 12 N.
2 050 000 FEET
2 030 000 FEET
1 Mile
5000 Feet
Scale 1:20000
NORTH CANADIAN
Sixmile Creek
CHICAGO ROCK ISLAND AND PACIFIC
SPOIL
AREA
Purcell Creek
Banner
1
2
4
5
6
7
8
9
11
12
13
14
16
17
18

(39)



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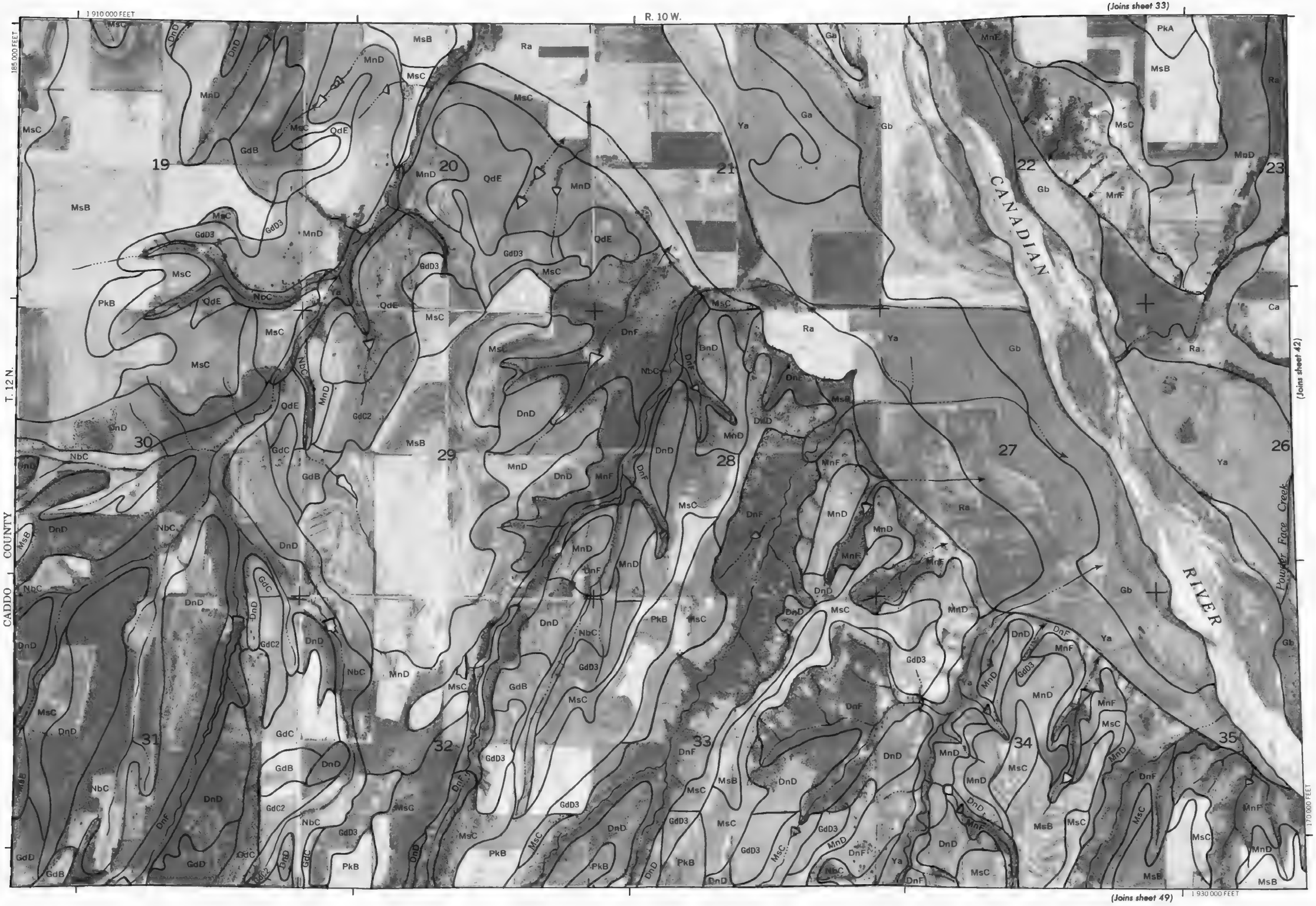

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N

(Joins sheet 36)

R. 8 W.

2 000 000 FEET

1 Mile

5000 Feet

Scale · 1 : 20000

(Joins sheet 43)

T. 12 N.

180 000 FEET

170 000 FEET

1 980 000 FEET

(Joins sheet 52)

(Joins sheet 45)

Creek

Fourmile

20 21 22 23 24

29 28 27 26 25

32 33 34 35 36

NrB GpE NrC BeA RcC2 KrB RbB PkB PkA KsB NrD Po KrA

N

2 005 000 FEET

R. 7 W.

(Joins sheet 37)

EL RENO
(county seat)

BORROW PIT

CHICAGO, ROCK ISLAND AND PACIFIC

Creek

Sixmile

T. 12 N.

180 000 FEET

(Joins sheet 44)

(Joins sheet 46)

170 000 FEET

2 025 000 FEET

(Joins sheet 53)

1 Mile
5000 Feet
Scale 1:20000

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Roads shown are approximately positioned
Coordinate grid ticks and land division corners (if shown) are approximately positioned

N

(Joins sheet 38)

R. 7 W. | R. 6 W.

2 050 000 FEET

3 LANE

1 Mile

5000 Feet

Scale 1:20000

0 0

¼ 1000

½ 2000

¾ 3000

1 4000

5000

23 24 19 20 21

26 25 30 29 28

35 36 31 32 33

T. 12 N.

180 000 FEET

170 000 FEET

(Joins sheet 45)

(Joins sheet 47)

(Joins sheet 54)

2 030 000 FEET

BeA NrB NrC PkA KrA KrB KsB Po Pd GpE GhB KfB NaD NaD2 NaD3 Da Pw Wa Mc RbB RcC2

N

2 055 000 FEET

R. 6 W. | R. 5 W.

(Joins sheet 39)

180 000 FEET

T. 12 N.

(Joins sheet 46)

(Joins sheet 48)

(Joins sheet 55)

2 070 000 FEET

170 000 FEET

1 Mile

5000 Feet

Scale 1:20000

YUKON

Shell

Mc Creek

(48)

N

(Joins sheet 40)

R. 5 W.

2 095 000 FEET

YUKON

Lake Overholser

T. 12 N.

180 000 FEET

OKLAHOMA COUNTY

1 Mile

5000 Feet

Scale 1:20000

(Joins sheet 47)

170 000 FEET

2 075 000 FEET

(Joins sheet 56)

NORTH CANADIAN

BORROW PIT

CHICAGO, ROCK ISLAND AND PACIFIC

GULF, COLORADO AND SANTA FE

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Coordinate grid ticks and division corners shown are approximately positioned

1 960 000 FEET

R. 9 W.

R. 8 W.

(Joins sheet 43)

165 000 FEET

T. 11 N.

(Joins sheet 50)

CANADIAN RIVER

1 975 000 FEET

(Joins sheet 59)

(Joins sheet 52)

155 000 FEET

51

N

Scale · 1:20000

1 Mile

5000 Feet

52

N

(Joins sheet 44)

R. 8 W.

2 000 000 FEET

T. 11 N.

165 000 FEET

(Joins sheet 53)

(Joins sheet 51)

155 000 FEET

1 980 000 FEET

(Joins sheet 60)

1 Mile 5000 Feet

Scale · 1 : 20000

0 1000 2000 3000 4000 5000

1/4 1/2 3/4 1

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2 005 000 FEET

R. 7 W.

(Joins sheet 45)

165 000 FEET

T. 11 N.

(Joins sheet 52)

(Joins sheet 54)

(Joins sheet 61)

2 025 000 FEET

53

N

1 Mile

5000 Feet

Scale 1:20000

BeA KrB KrA NrB NrC NrD PkA Po RcC2 KsB GpE GhB VrE RbB VsC2 PkB Pw

Sixmile Creek

Arapaho Creek

PACIFIC AND ROCK ISLAND

CHICAGO

BORROW PIT

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57

N

1 Mile 5000 Feet

Scale 1:20000

0 ½ 1 2000 3000 4000 5000 1000

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Coordinate grid ticks and land division corners, if shown, are approximately positioned

60

N

(Joins sheet 52)

R. 8 W.

2 000 000 FEET

150 000 FEET

T. 11 N.

(Joins sheet 59)

(Joins sheet 61)

(Joins sheet 65)

1 980 000 FEET

140 000 FEET

Scale 1:20000

1 Mile 5000 Feet

0 0 ¼ 1000 ½ 2000 ¾ 3000 1 4000 5000

RIVER

CANADIAN

GRADY COUNTY

20 21 22 23 24 25 26 27 28 29 32 33 34 35 36

Ca Po NrB RbB RcC2 PkB NrC NrD PkA BeA KrB GpE KsB Ga Mc Da Ra Gb Ya MsC MnF MsB DnD MnD Tv Wa

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Coordinate grid ticks and land division corners if shown are approximately positioned

61

N

2 005 000 FEET

R. 7 W

(Joins sheet 53)

150 000 FEET

T. 11 N.

(Joins sheet 60)

(Joins sheet 62)

140 000 FEET

(Joins sheet 66)

2 025 000 FEET

1 Mile

5000 Feet

Scale 1:20000

Chicago, Rock Island and Pacific

Union City

Arapaho Creek

Arapaho Creek

N

(Joins sheet 54)

R. 7 W. | R. 6 W.

2 050 000 FEET

1 Mile

5 000 Feet

0 0

Scale 1:20000

¼ 1 000

½ 2000

¾ 3000

1 4000

5000

(Joins sheet 61)

140 000 FEET

T. 11 N.

150 000 FEET

(Joins sheet 63)

(Joins sheet 67)

2 030 000 FEET

Beaver Creek

Creek

2 055 000 FEET

R. 6 W. | R. 5 W.

(Joins sheet 55)

63

N

150 000 FEET

T. 11 N.

(Joins sheet 64)

(Joins sheet 62)

140 000 FEET

(Joins sheet 68)

2 070 000 FEET

1 Mile
5000 Feet
Scale 1:20000
0 1000 2000 3000 4000 5000

Mustang
Creek
Foreman
Bennett Creek
Lakeside

64

N

(Joins sheet 56)

R. 5 W.

2 095 000 FEET

150 000 FEET

T. 11 N.

OKLAHOMA COUNTY

1 Mile

5000 Feet

Scale 1:20000

(Joins sheet 63)

140 000 FEET

2 075 000 FEET

(Joins sheet 69)

MUSTANG

SAN FRANCISCO

Canadian City

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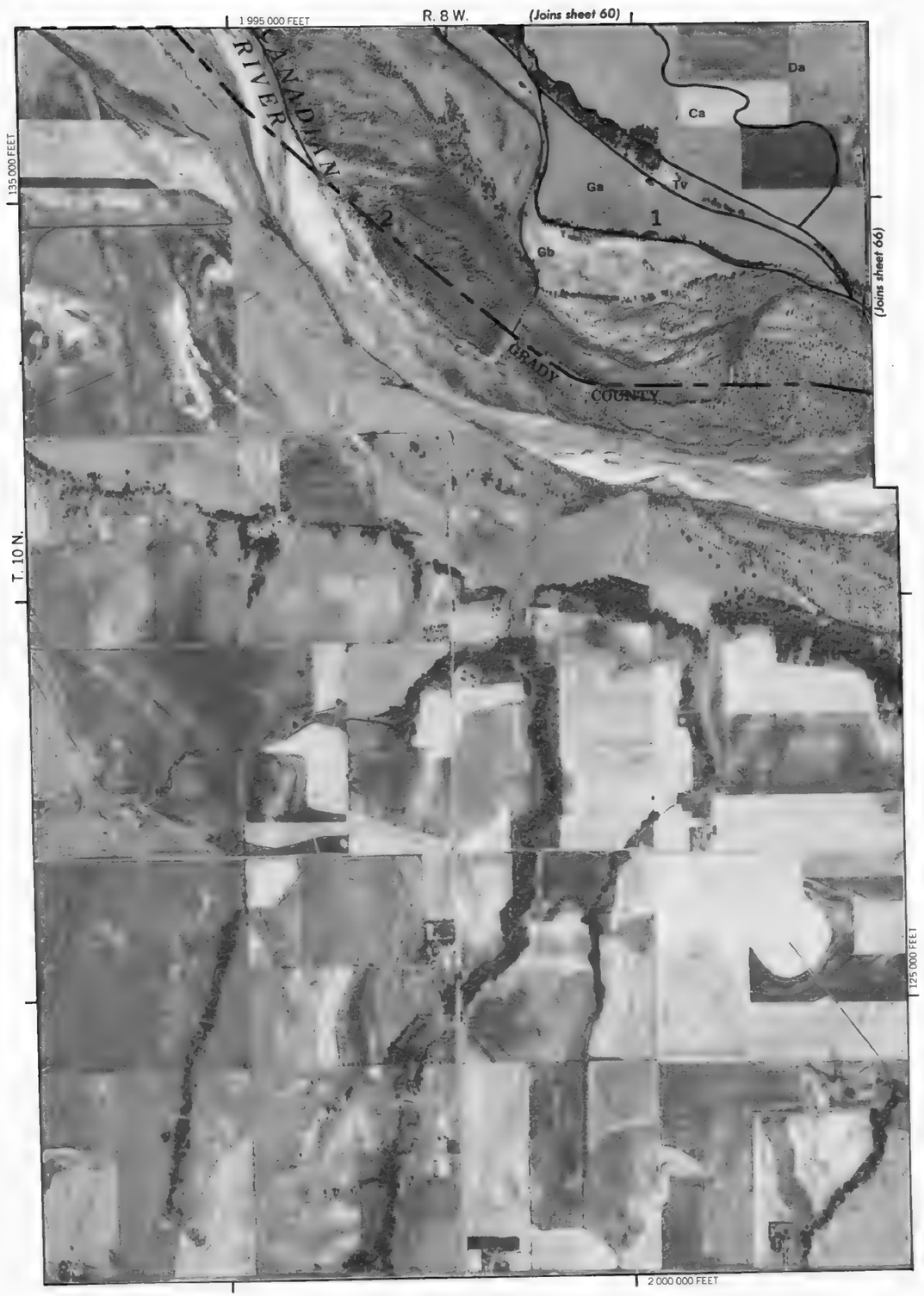
Soil boundaries shown are approximately positioned
Coordinate grid ticks and land division corners shown are approximately positioned



65

N

1 Mile
5000 Feet

Scale 1:20000

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2 075 000 FEET

R. 5 W.

(Joins sheet 64)

135 000 FEET

T. 10 N.

(Joins sheet 68)

(Joins inset, sheet 66)

2 095 000 FEET

125 000 FEET

N

1 Mile

5000 Feet

Scale · 1:20000

CLEVELAND COUNTY

MC CLAIN COUNTY

GRADY COUNTY

CANADIAN RIVER

Camp Kickapoo